REFRIGERATION & AIR CONDITIONING

STUDY AND RECOMMENDATIONS

By

Sub-Committee of Task Force
on National Strategy for Phasing Out
of Ozone Depleting Substances

December 1991

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1. INTRODUCTION

The Department of Industrial Development, Ministry of Industry, Government of India vide letter No.10(1)/88-Paper(TP&TD)/FC(I) dated 29.5.91, has constituted a Task Force to formulate the "National Strategy for phasing out Ozone Depleting Substances and for adoption of Substitute Substances/Technologies" under the Chairmanship of Sh N.R. Krishnan, Addl. Secretary, Deptt. of Industrial Development. The task force, in its first meeting on 7.6.91, decided to form a sub-group on 'Refrigeration and Air Conditioning' to look into all aspects of the above subject more closely in respect of this sector. The constitution of the sub-group is given in Appendix I.

The Ozone Depleting Substances (ODS) of relevance to this sector are the 'Chloro Fluoro Carbons', more commonly referred to as CFCs

The terms of reference decided for the sub-group are :

1. a) To assess the present and future demand potential of CFCs used in this sector.

   b) To assess indigenous availability of CFCs.

2. To evolve a national R&D strategy for phasing out CFCs to 'Ozone friendly substances' and related technologies.

3. To work out the transition plans.

4. To work out the costs for phasing out CFCs with suitable substitutes and technologies.

5. Recovery and recycling technologies.

6. Technology transfer mechanism, fiscal incentives, legislative actions to implement transition/phase-out programme.

7. To suggest modifications, if any, to the Montreal Protocol which can be taken up in appropriate International forum.

The sub-group held four meetings on 21.6.91, 16.7.91, 20.8.91 & 11.11.91 based on which this report is prepared and finalised.

2. EXECUTIVE SUMMARY

In response to the worldwide concern about the Ozone Depletion, the Montreal Protocol, on substances that deplete the ozone layer, was agreed in 1987. Some of the chlorinated and brominated fluorocarbaons (CFCs), currently used in the Refrigeration and Air Conditioning (RAC) sector, are included in the list of controlled substances in terms of the Montreal Protocol. The Protocol lays down the time schedule for the 'freeze' in production and 'reduction' in the "consumption" of the Ozone Depleting Substances (ODS).

Events subsequent to the signing of Montreal Protocol and the further scientific studies made during 1987-90 have resulted in amendments to the Montreal Protocol in June 1990 which aim at accelerating the process of 'reductions' to an eventual phase out.

Today, over 58 countries and the European Community have signed and ratified the Protocol. Many of the 160 developing countries including India are yet to sign the Protocol.

The Government of India is actively considering the signing of the Protocol and has constituted a task force to formulate the "National Strategy for phasing out Ozone Depleting Substances and for adoption of Substitute Substances/Technologies".

The Refrigeration and Air Conditioning sector in India accounts for a significant percentage of total CFC's presently used. The percentage (including rigid foams used in insulation for energy conservation) in refrigeration industry is nearly 74% as compared to worldwide consumption of only 30% (This report considers 55% of such uses, balance uses for energy conservation in Refrigeration and Air Conditioning industry are considered under Aerosol, Foam and Cleaning). In tropical and developing countries like India, use of CFC assumes vital proportions. Food preservation, vaccine preservation, drug and pharmaceutical manufacture are key developmental programmes where use of CFC is of critical importance to India.

The Task Force has, therefore, formed a Sub-group for 'Refrigeration & Air Conditioning' to look closely into all aspects of the subject in respect of this sector and propose a strategy comprising of initiatives, incentives and measures for phase out of CFCs without affecting the growth or working of the industry in a serious way.

This report is the result of extensive discussions held by this Sub-group in various meetings.

Montreal Protocol and Its Implications to India

The amended protocol lays down the time schedule of 'freeze' and 'reduction' of the Controlled Substances.

According to the amended protocol, reduction scheme for these substances is in the following time schedule :

MAJOR CHANGES IN PHASE-OUT SCHEDULE ADOPTED AT JUNE 1990 - LONDON CONFERENCE

SUBJECT	MAJOR ADJUSTMENTS		
CHLOROFLUOROCARBONS (CFC-11,12,113,114 & 115)	DEVELOPED COUNTRIES (Year)	Cut in PRODUCTION/ CONSUMPTION (from base year)	DEVELOPING COUNTRIES (Year)
Base Year Developed Nations - 1986 Developing countries- (average for the period between 1995 to 1997)	1989	FREEZE	1999
	1995	50%	2005
	1997	85%	2007
	2000	100%	2010

The trends of actions on CFCs and HCFCs in the world indicate that the phase out of CFCs may be accelerated further and HCFCs which presently are not controlled by the Protocol and which are regarded as "Transitional Substances" are also being considered for phase out even though they have much lower ODP.

Recommendations made in this report are based on the assumption that India will sign the protocol in the next six months and on the basis of the current status of scientific and technical knowledge on the subject.

It is expected that each sector of industry will evolve mechanisms for control as per the Montreal Protocol limits. These mechanisms need to be integrated to formulate the National Strategy for phase-down of Group I substances of Annex I of the Protocol.

The phase out strategies suggested in this report are for R&AC sector only and this has to be considered together with similar strategies formulated by other sub-groups to formulate the National CFC Phase Out strategy. To this extent these proposals are tentative, subject to modifications.

Current and Forecast of Demands for Ozone Depleting Substances in Refrigeration and Air Conditioning Sector

The purpose of assessing the present and future demand of CFCs in the refrigeration and air conditioning sector is to establish the consumption figure for 1996 which is taken as the base for 'freeze' and progressive 'reduction' as per the time schedule of the Protocol. (In practice average of 1995 to 1997 consumption shall be taken as base figure. For convenience, this report considers consumption figure of 1996 as the 'base' figure).

The current and forecast demand for the controlled substances in refrigeration and air conditioning (RAC) sector has been assessed based on exhaustive data collected and discussions held among the RAC equipment manufacturers, CFC manufacturers and the scientists working in this field. Considering the production and the existing population data for each appliance and the amount of charge and recharge used, the CFC's consumption have been estimated. The CFC used for making PU foam for insulation ONLY for refrigerators, deep freezers, bottle and visi coolers has been taken into account. The growth rate for each appliance has been evolved considering the production data of previous years and the demand patterns.

The following table shows the forecast of CFCs and HCFC-22 consumption considering unrestrained growth till the year 2010 at the 'Milestone' years of the Montreal Protocol.

Consumption Figures of CFCs and HCFC-22 in RAC Sector

(Metric Tonnes)

CFCs	1990	1996	2000	2005	2007	2010
CFC-11	497	1633	2823	4653	5755	7849
CFC-12	1630	2690	4748	6393	7687	10172
Total	2127	4323	7571	11046	13442	18021
HCFC-22	2132	3820	5651	9509	12043	15931

According to the Montreal Protocol, the 'freeze' is to be achieved from 1-1-2000 i.e., consumption is to be reduced to that of the reference year (1996) figure.

Indigenous Availability of CFCs

The CFCs presently manufactured in the country are CFC-11 and CFC-12 (controlled by the Protocol) while the only HCFC manufactured is HCFC-22 (not controlled by the Protocol). There are five manufacturers of these chemicals in the country. The total present production is about 6100 MT. The total installed capacity of five plants is 18700 tonnes per year. This capacity can easily be increased to 20200 tonnes by minor debottlenecking.

All the CFC plants have the capacity for manufacturing HCFC-22 and the production can be switched over from CFCs 11 and 12 to HCFC-22. Thus, the country has the capacity of meeting the increased demand of HCFC-22 arising due to the switch over to HCFC-22 in place of CFCs in some of the RAC appliances and also due to the growth of appliances which use HCFC-22, at least till 2007.

Substitute Substances and Their Availability

The vast majority of present RAC appliances utilize the vapour-compression (VC) cycle because of its simplicity and good efficiency. The dominance of this cycle is not likely to change due to the need to replace the CFCs.

Although apart from CFCs and HCFCs, some inorganic refrigerants, like ammonia, are being used for some applications in vapour compression refrigeration systems, CFCs/HCFCs are the most prevalent refrigerants.

The products in refrigeration and air conditioning sector can be grouped in two categories :

Category I	Category II
Refrigerator	Water Cooler
Deep Freezer	Central A/C Plants
Bottle Cooler	Cold Store
Car A/C	Room A/C
Bus and Van A/C	Package A/C
Train A/C	Shipping RAC equipment
	Ice Candy Machines

Category II products either use HCFC-22 or CFC-12 at present. They can, however, be switched over easily to HCFC-22 technologies as this fluid is not a 'controlled substance'.

Category I products use CFC-12 or CFC-11 as refrigerants and CFC-11 as the blowing agent to manufacture PU foam insulation. From the point of view of refrigeration and air conditioning sector, it is for this category CFC-free substitutes have to be found.

The greatest impediment, however, in selecting, developing and commercializing alternative refrigerants is the uncertainty regarding the relative weight to be given to ozone depletion potential, greenhouse warming potential, cycle efficiency and safety factors such as toxicity and flammability. Since this uncertainty will not get resolved, a wide range of possible alternative refrigerant should be explored.

As on date, HFC-134a is regarded as most promising alternative for CFC-12 and a large number of chemical manufacturers abroad are establishing plants for manufacture of HFC-134a. A large number of compressor manufacturers are also at an advance stage of manufacturing compressors based on HFC-134a. However, PAFT result for toxicity is expected to be announced in 1992. The issues on Global Warming arising out of emissions of HFC-134a and also due to extra emission of CO_2 as a result of higher energy consumption in products using HFC-134a are presently being analysed. We, therefore, need to wait till these issues are resolved. Gas manufacturers are concerned that process of manufacture of HFC-134a involves more than one step, process-efficiencies presently achieved are lower and costs of setting up the plant are higher.

The other alternative refrigerant is the ternary mixture of HCFC-22/HFC-152a/HCFC-124 which is also considered to be a drop in substitute. There is some support to HFC-152a, however, the issue of flammability of this compound is of great concern to RAC equipment manufacturers. Gas manufacturers, however, find that the process of manufacture of HFC-152 simpler.

HCFC-123 is widely regarded as an alternative to CFC-11. However, the recent toxicity tests have created some concern. HCFC-141b is another alternative proposed for CFC-11 but it is flammable and substantial equipment change will be called for. PAFT test result for toxicity will be known only after 1993. As on today, it appears that the search for a suitable substitute for CFC-11 is not over.

We need to resolve whether the best alternatives are those adopted worldwide (in order to retain the export market and minimize the cost of technology development) or those which are environment friendly and which are permanent substitutes not requiring yet another phase-out. The right choice of course will be combination of above.

A clear picture on the substitutes and technologies is expected to emerge in the next one or two years. This need not cause concern in Indian context as we have a grace period of 10 years available over the developed countries for phase out.

Phase Out Strategies for Refrigeration and Air Conditioning Sector

For the purpose of evaluating the incremental switch-over costs arising out of compliance with the Protocol, two scenarios are visualized (Early substitution - Scenario I and Late substitution - Scenario II). These scenarios take into account the various CFC control and phase out mechanisms and other considerations such as the prioritization for phase out between different products within the refrigeration and air conditioning sector, recharging after the year 2010, quantum of CFC consumption in a product and the level of technology of products.

The salient features of two phase out scenarios are given below :

Date	Early Substitution - Scenario I	Late Substitution - Scenario II
1.1.1999	50% CFC-12 phase-out in compressors of Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12	--
1.1.2000	- 100% CFC-12 phase out in Refrigerators, Deep Freezers, Bottle Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12	- 50% CFC-12 phase-out in Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Centrifugal Chillers and Mobile A/C based on CFC-12
	- 100% conversion of CFC-12 compressors of Central Plant, Cold Store, Ice Candy Machines and Room A/C to HCFC-22	- 100% conversion of CFC-12 compressors of Central Plant, Cold Store, Ice Candy Machines and Room A/C to HCFC-22
	- 50% CFC-11 reduction in foam	- 50% CFC-11 reduction in foam

Date	Early Substitution - Scenario I	Late Substitution - Scenario II
1.1.2005	- 100% change over of CFC-11 Centrifugal Chiller by CFC-11 substitute	- 100% change over of CFC-12 by CFC-12 substitute in Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12.
	- 100% CFC-11 reduction by CFC-11 substitute in foam of Refrigerators, Deep Freezers and Bottle Coolers.	- 100% change over of CFC-11 by CFC-11 substitute in foam and Centrifugal Compressors
1.1.2010	- Residual recharging requirements to be met by recovery/recycling or drop-in substitutes or retrofitting the Compressors.	- Residual recharging requirements to be met by recovery/recycling, or drop-in substitutes or retrofitting the Compressors.

Early Substitution - Scenario I is based on the assumption that CFC-12 substitutes and technology for manufacture of substitutes/appliances/products are available by 1996/1997 and similarly CFC-11 substitutes and technology for manufacture of substitutes/appliances/products are available by 2000/2001. This scenario shows that the number of appliances/products requiring recharging or scrapping or are needed to be destroyed by approved destroying technologies in 2010 are less. This scenario brings CFC consumption in year 2000 at lower level than expected by the protocol but still exceeds the protocol levels after 2007.

It should be noted that freeze in developed countries started in 1989 (at 1986 level). No phase out/phase down has been made by the developed countries in refrigerators till now (1991 end) eventhough they will have larger residual refrigerators for recharging/abandoning in the year 2000.

Late Substitution - Scenario II is based on the assumption that CFC-12 substitutes and the technology for the manufacture of substitutes/appliances/products are available by 1997-98, however, the CFC-11 substitutes and the technology for manufacture of substitutes/appliances/products are available by 2000-2001 (as assumed in Early

Substitution - Scenario I). In this scenario, the consumption could not be contained to the 'freeze' level between 1999 and 2000. It also shows the crossing of the limits in the year 2003, 2005 and 2007. The situation can, however, change in the National Phase-out Strategy where CFC consumption in other sectors will also be considered and when it may be possible to adopt CFC-free technologies earlier.

Figure 2.1 shows the reduction of consumption of CFCs in this sector in terms of the two scenarios against the backdrop of the Montreal Protocol schedule applied to THIS SECTOR ONLY.

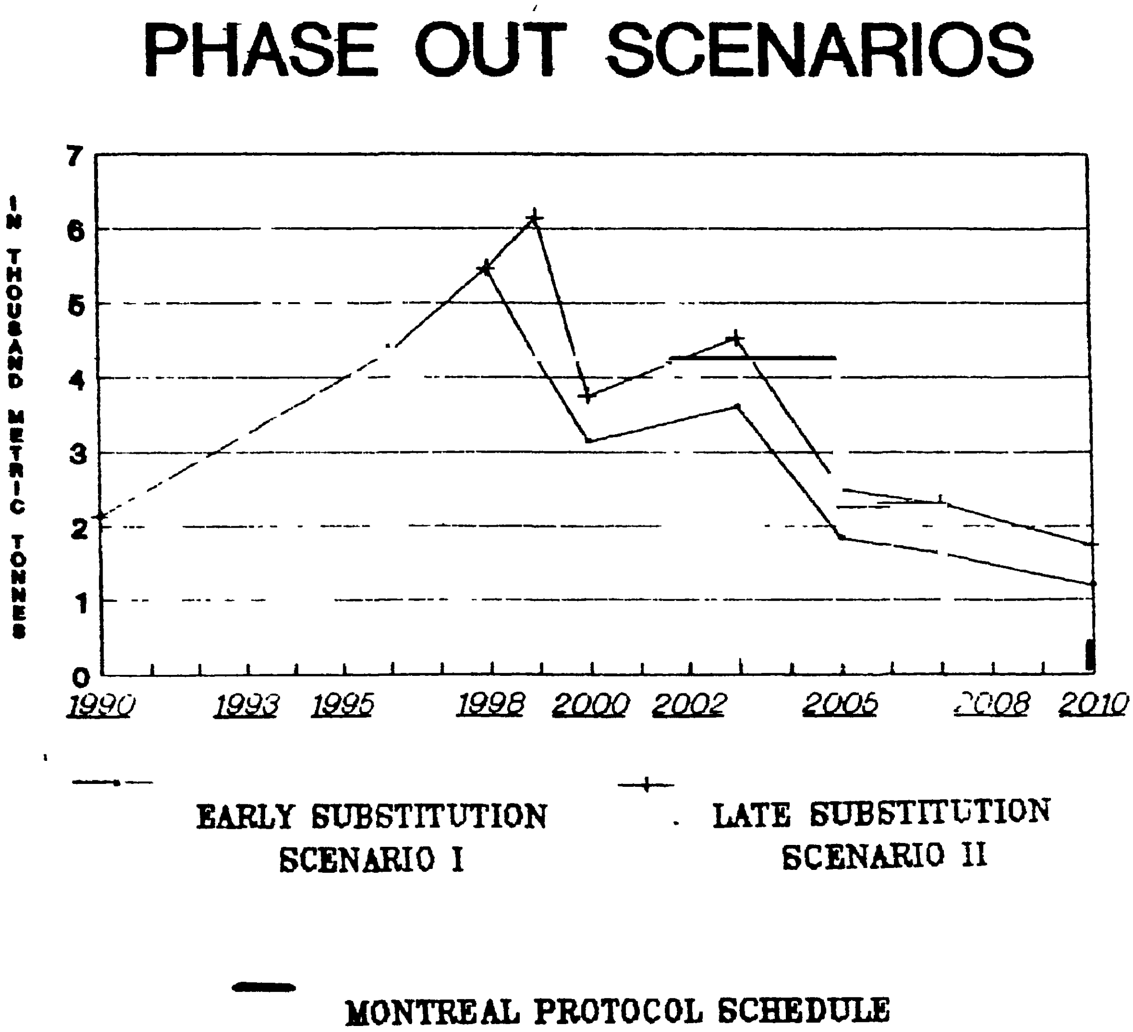

FIG-2.1

If 5000 tonnes is assumed as an economical quantity for manufacture of CFC substitute, this demand will be reached around the year 2007 for the CFC-12 substitute and by 2005 for CFC-11 substitute. The plants for the same can be planned accordingly to meet the above requirements. It may be necessary to plan the manufacturing facilities with smaller capacities to avoid large imports.

Emission Reduction, Recovery and Recycling

Both scenarios bring out that emission control through better manufacturing and service practices, the recovery and recycling technologies and switch over to HCFC-22 in the suggested products be accorded the highest priority.

The seriousness of this aspect can be appreciated from the following observations :

a) The recharging demand of the refrigerants CFC-11 and 12 in refrigerating equipment arising out of leakage, venting and scrapping form about 55% of the CFC consumption in 1990.

b) In an unconstrained CFC consumption scenario this percentage is 46% by 2010 and is almost 191% of the base figure in 1996 for Montreal Protocol implementation. The Protocol requires this consumption should be brought to zero by 2010.

c) Even in the two phase out scenarios proposed in this report, it is found extremely difficult to reduce the CFC demand on account of recharging to less than 15% let alone the zero percent to be achieved as per the Protocol.

Substantial reduction of CFC emissions can be realised through :

a) Minimising the requirements of refrigerant through suitable equipment redesign.

b) By adopting better manufacturing and servicing practices where refrigerant goes into the atmosphere through leakages and venting and

c) Recovery and recycling of refrigerant.

Following strategies for effective control of emissions recovery and recycling are suggested :-

1. Study and analysis of various measures for reduction and controlling the CFC emissions along with recycling and recovery. This study should consider practices followed abroad and special . situation existing in India.

2. A CODE OF PRACTICE TO CONTROL EMISSIONS IN MANUFACTURE OPERATIONS AND SERVICING OF REFRIGERATION AND AIR CONDITIONING EQUIPMENT IS TO BE IMMEDIATELY PREPARED.

   THIS MAY BE ASSIGNED AS A CONSULTANCY PROJECT INVOLVING ISHRAE AND INDUSTRY IMMEDIATELY.

3. Industries in the Pollution Control business may be encouraged to develop the recovery and recycling equipment.

4. Exemption of excise duty and other fiscal benefits may be provided for purchase of these equipment so that mechanics, service stations, manufacturing companies and users can be encouraged to buy and utilise the equipment.

5. In some countries, it is mandatory for service stations to own a recovery equipment. A similar regulation can be considered.

6. A further rebate in price can be considered on the deposit of recovered gas at authorised recycling station.

   Initially, in all major cities (A, B abd C) Authorised recycling stations may have to be established at the Regional Offices of the CFC manufacturers.

7. It will be necessary to make provision in the design of the equipment for mechanisms for recovery of refrigerants from refrigerators/air conditioners. There is a need for standardisation of the valves and quick couplers and the tubes for this purpose. The Bureau of Standards in collaboration with the Industry Association like ISHRAE, AIARCON and IIT's or other research institutes can prepare these standards.

8. IT IS NECESSARY TO COMMISSION A CONSULTANCY ORGANISATION TO STUDY ALL ASPECTS OF SCRAPPING OF REFRIGERATORS, AIR CONDITIONERS ETC. AND COST OF EITHER RECYCLING OR INCINERATION.

Research and Development Strategies

Changing over from CFCs to Ozone friendly substitutes in terms of technology, processes, products and servicing practices is the major revolution of the century in the field of Refrigeration and Air Conditioning Sector (Presently valued at Rs.3000 Cr.). The efforts required in terms of education of technical personnel and customers, Research & Development required for evaluation, establishment and implementation of substitute technology and development of emission control technology are massive.

A comprehensive R&D strategy is, therefore, formulated with the following objectives :

- Development of Data base
- Evaluation and assessment of the substitutes to provide technical support to the Indian industry for adoption of appropriate substitutes under Indian conditions including export.
- Development of recycle and recovery methods.
- Development of CFC free technologies for refrigeration and air conditioning applications.

The details of R&D programmes are spelt out in Section 9 of the report.

THE SUB-GROUP RECOMMENDS THE ESTABLISHMENT OF NATIONAL CENTRE FOR REFRIGERATION AND AIR CONDITIONING. ONE OF ITS DIVISIONS COULD BE ASSIGNED THE RESPONSIBILITY FOR PROMOTING THE RECOVERY AND RECYCLING TECHNOLOGIES. THE CENTRE CAN ALSO PROVIDE ASSISTANCE TO THE UNORGANISED SECTOR ON BETTER METHODS OF PROCESSING AND MANUFACTURING AND ALSO TO COPE WITH THE DESIGN CHANGES BROUGHT OUT BY THE SUBSTITUTION OF CFCs BY OZONE FRIENDLY CHEMICALS.

IMMEDIATE STEPS ARE ALSO REQUIRED FOR FUNDING THE R&D PROGRAMMES ON SUBSTITUTES FOR CFCs WITH COLLABORATION OF LABORATORY, INDUSTRY AND INTERNATIONAL SCIENTIFIC ASSOCIATIONS IN THIS AREA, SO THAT RESULTS ON EVALUATION OF THE SUBSTITUTES UNDER INDIAN CONDITIONS ARE AVAILABLE BY 1996 TO PREPARE THE INDUSTRY FOR THE CFC PHASE OUT.

The costs for the R&D strategies for phase out is estimated at $ 200 million (Rs.50 Crores) and this amount must be obtained from the Multinateral fund being created under the aegis of UNEP. A COMMITTEE MUST BE IMMEDIATELY CONSTITUTED TO PREPARE THE R&D PROJECT PROPOSALS.

Incremental Costs of Phase Out

Incremental costs for phasing out CFCs will be incurred by all the affected segments - CFC producers, producers of associated chemicals like polyols, lubricants, Refrigeration and Air Conditioning equipment/appliance manufacturers, compressor manufacturers, and users of equipment/appliances. The effect will also be felt by the consumer in terms of increase in price and operational costs.

The estimated incremental costs for phasing out as per Early Substitution - Scenario I and Late Substitution - Scenario II (calculated on the basis of 1991 rupee value) is given below :

Costs	Early Substitution - Scenario I	Late Substitution - Scenario II
Costs to CFC Producers	400 crores	400 crores
Costs to R&AC equipment manufacturers	370 crores	370 crores
R&D Costs	50 crores	50 crores
Costs to consumers for scrapping/abandoning .	2259 crores	4767 crores
Total in Rupees (1991)	3079 crores	5587 crores
TOTAL IN MILLION US$ (1 US$ = Rs.25.50)	1207	2190

This does not include the cost of destroying technologies for refrigerator foams which is estimated at Rs.5570 crores ($ 2184 million). The magnitude of the figure should, however, be kept in mind in any future discussions on Montreal Protocol which may call for implementing destroying technologies also.

It must be emphasized that costs to consumers for scrapping will get reduced if 'drop-in' substitutes (like Ternary blends of HCFC-22, HFC-152a and HCFC-124) are made available. These blends can be used for recharging the equipment which have useful life even after 2010.

Measures to Achieve Phase Out

Once India becomes a signatory to the Montreal Protocol in 1992, the limits on consumption of Ozone Depleting Substances will come into force. The Government will have to ensure that these limits are adhered to, without in any way prejudicing the progress/ growth of the industries involved, or discouraging the demand from the consumer or without any 'economic drag'.

A combination of 'Market based measures' with 'Command and control' measures will be required as a part of the programme to phase out the ODS substances. These are :

- To encourage the growth of demand of R&AC appliances/ products through excise duty and sales tax relief so that a high figure of CFC consumption can be built by 1997 for the 'base'.
- To decide quotas on production/consumption at the producer level in 1988 for gas and equipment/product manufacturers.
- To provide financial incentives to close production capacity for products containing CFC and establish capacity for products containing CFC substitutes or to convert the existing capacity to the production of products containing substitute substances.
- Assistance with technology transfer for compressors, based on Ozone friendly substitutes and for new foaming systems through customs duty reliefs.
- Compensation to the ultimate consumer against price increase through reduction of excise duty.
- Graded system of taxation on products containing CFCs beyond 2000 which increase over a time upto 2010.
- Encouragement to R&D aimed at retrofitting of new compressors, recycling and recovery schemes.
- Loans/grants at nominal interest for modernisation of plants to cope up with the CFC substitutes.
- Discourage import of technology based on CFCs after 1996.
- Discourage upto 1996 commercial import of CFC-substitutes and related technologies till they are well evaluated under Indian conditions as indicated in R&D strategies.

Encourage commercial import of CFC-substitute and related technologies as have been well evaluated under Indian conditions after 1996.

To ensure that producers, users and consumers become convinced of the Government's commitment, the following actions of the Government are necessary :

- The measures taken are well publicized to all affected groups.
- The reasons for each measure and its intended effect are explicitly stated.
- Intention to implement particular measures are announced as early as possible.
- The time table for applying measures is announced as early as possible.
- Measures which have a direct impact on the price to the customer are applied gradually.

It will be necessary for the Government to create an Agency/Board to monitor the implementation of the phase out strategy, the effect of measures taken and reduce the grievances/problems that may arise expeditiously.

The tentative action plan and the measures suggested is given hereunder.

Year	Action Needed	Measures required for implementation/ Agency for Monitoring
1992	Announcement of India accepting Montreal Protocol	Public notice by Govt. of India by Ministry of Environment in all leading newspapers drawing the attention of affected parties.
	Amendment of Air Pollution Control Act 1981 to include CFC within its scope	Parliament
	Establishment of National Centre for Refrigeration & Air Conditioning	Department of Science & Technology
	Creation of a Board for implementation & monitoring of phase out strategy.	Department of Environment
	Sponsoring & funding of projects identified in R&D strategy including evaluation programme.	Deptt. of Science & Technology

Year	Action Needed	Measures required for implementation/ Agency for Monitoring
1993	Start of Evaluation Programme	Jointly with Industry.
1994	Monitoring the production & consumption of CFCs in India	DGTD/Board for CFC phase out
	Ban of the use of CFC-12 in Air Conditioner, large Water Coolers and Cold Stores effective from 1.1.1998	DGTD/Board for CFC phase out
1996	Completion of evaluation programme	Jointly with Industry.
1998	Announcement of the 100% base for the Montreal Protocol Control	DGTD/Board for CFC phase out
	Limiting of production & consumption of CFCs through quota system.	DGTD/Board for CFC phase out
	Incentives for reduction in consumption of CFCs to be announced.	Department of Finance
	Import Policy of the CFCs substitute to be announced	Department of Commerce
	Modification of Licensing Policy for Refrigeration & Air Conditioning products in line with CFCs phase out policy.	Department of Industrial Development
	Incentives for purchase/import of recovery & recycling equipment.	Department of Industrial Development
	Incentives for recovery and/or recycling of CFCs gases	Department of Industrial Development
	Incentives for modification of Refrigeration & Air Conditioning equipment to facilitate recovery & recycling equipment.	Department of Industrial Development
	Incentives in industrial policy for import of know-how & technology for Refrigeration & Air Conditioning equipment based on CFCs substitute.	Department of Industrial Development

Recommendations

1. We should sign the Montreal Protocol as an environmentally conscious nation.

2. Immediate steps should be taken :

   a) To establish an Administrative agency etc. to work on all aspects of CFC phase out including monitoing and measures to be taken.

   b) For the establishment of a National Centre for Refrigeration & Air Conditioning.

   c) To fund the comprehensive R&D programmes detailed in Chapter 9.

   d) To assign a consultancy project to develop 'Codes for better manufacturing and servicing practices'.

3. This report is prepared based on present level of knowledge on CFCs substitutes and the present status of the Protocol. It will be necessary to update the report regularly.

   A standing committee with a small secretariat will have to be provided.

4. On issues related to the Montreal Protocol, the Government may insist on :

   a) A uniform norm of calculated level of per capita consumption for all the countries beyond 2000.

   b) Flexibility in phase down schedule for various Ozone Depleting Substances (within the Montreal Protocol limits and framework) depending on importance of a particular substance to the tropical climate and developing economy of India.

   c) Extra grace period of 5 years, if Greenhouse Warming Potential becomes a determining factor for the choice of CFC substitutes.

   d) Continued and unhindered use of HCFC-22 to be reaffirmed by the Parties.

   e) Separate quantum of assistance if Destructing Technologies are to be implemented.

3. THE MONTREAL PROTOCOL AND AMENDMENTS

3.1 The Montreal Protocol

There is strong scientific evidence that damage to the ozone layer is being caused by some of the chlorinated and brominated fluorocarbons. Some of these substances are being used in industrial and domestic products for many years.

In response to worldwide concern at Ozone Depletion, the Montreal Protocol, on substances that deplete the Ozone layer, was agreed in 1987. Today, over 58 countries and the European Community have signed and ratified the Protocol of 1987 and have therefore become 'Parties'.

Many of the 160 developing countries have yet to sign the Protocol.

The definitions of 'Key Words' related to the Protocol are indicated in Appendix II.

3.1.1 Control Measures of the Protocol

The Protocol lays down the time schedule for 'freeze' and 'reduction' of production and consumption of the controlled substances. The controlled substances which are of relevance here are segregated into two groups.

Group 'I' of Annex A of the Protocol contains CFCs 11, 12, 113, 114 and 115. These are fully chlorinated fluorocarbons and contain no hydrogen.

Group 'II' of Annex A contains halons 1211, 1301 and 2402. These are fully halogenated fluorocarbons containing Bromine and they contain no hydrogen.

The Annex A of the Protocol is included in this report as a part of Appendix III. HCFC's (i.e. hydrogenated chlorofluoro carbons) like HCFC-22 are presently not controlled by the Protocol.

Some of the significant features of the Protocol relevant to this report are the following :

1. The substances in each Group are considered in total, the so called "Basket Concept", allowing flexibility within the basket for Industry and Governments to achieve the required level of control.

2. It is significant that Protocol limits the "consumption" of CFCs rather than emissions to the atmosphere. Consumption is expressed in tonnes of substance multiplied by its ODP and is defined as 'Production' plus 'Imports' minus 'Exports' minus Quantities destroyed by Approved technologies.

3. Article 5 of the Protocol provides for developing countries (whose calculated per capita consumption is less than or equal to 0.3 kg) who become 'Parties' to the Protocol control to delay the compliance with the control measures by 10 years compared to the dates applying to the Developed Countries.

4. There are provisions within the Protocol for adjustment of the control measures based on scientific, environmental, technical and economic developments which will be reviewed at four yearly intervals.

3.2 June 1990 Amendments to the Montreal Protocol

Events subsequent to the signing of the Montreal Protocol have tended to speed up the phase out of the CFCs.

Studies made by Ozone Trends Panel (OTP) and WMO (World Meteorological Organisation) showed a seasonal dip of about 5 to 10% in the latitudes 53-64°N. UNEP meeting at Nairobi recognised the findings that between 30° - 64°N, the Ozone decreased from 3% to 1.7% as an annual average between 1969 to 1986.

Farman, the man who discovered the 'Ozone Hole' in Antarctic opined that the CFC emissions so far will continue to damage the Ozone Layer for decades and, even if the world community acts now, the worst stages of Ozone Depletion can be expected around 2020. He emphasised the reductions of CFC emissions down to 15% of the base level of 1986.

All these perceptions raised the question of the sufficiency of the reductions indicated in the Montreal Protocol of 1987. The first assessment to the Protocol took place in June 1990.

3.2.1 Amended Protocol

The amended protocol calls for a total phase out of the production and consumption of CFCs by 2000.

Appendix IV shows the revised phase-down dates as applicable to the developed and developing countries for CFCs. The amended Protocol also includes an expanded list of CFCs not covered by the original Protocol. This list, referred to as Annex B of the Protocol, is included in this report as a part of Appendix III.

HCFCs (Hydrogenated chlorofluorocarbons) are listed as "Transitional Substances" in Annexure C of the Protocol.

3.2.2 Amendments to the Protocol

From Indian point of view, the following amendments carried out in 1990 to the Protocol are of relevance:

Transfer of Technology

A new Article 10A of the Protocol was introduced to ensure the best available and environmentally safe 'Substitution and related technologies' are expeditiously transferred to developing countries.

Financial Mechanism

As per modified Article 10 of the Protocol, the Developed countries will contribute to the Multilateral Fund to meet all the incremental costs which developing countries have to bear to comply with the Protocol measures.

Special Situation of Developing Countries

Special situation of the Developing countries in regard to the Protocol has been well recognised in the Article 5 of the Protocol. It has been stressed that the capacity of the Developing Countries to comply with the implementation of measures will depend on the implementation of measures related to 'Financial Assistance and Transfer of Technology'.

Not later than 1995, the situation in regard to implementation of 'Financial Mechanism and Technology Transfer', as spelled out in the above paras, shall be reviewed in the meeting of the Parties and schedule of control measures shall be revised accordingly.

3.3 Trends of Actions on CFCs and HCFCs

As Governments, in terms of Montreal Protocol, are free to decide on unilateral and separate regulatory actions not contravening with the spirit of the control limits, several Western Countries notably Sweden, Holland and Germany have accelerated their CFC phase out time schedules and some of them have even announced phase out plans for HCFCs.

EEC has proposed a directive to phase out CFC's 100% by 1998, although the amended June '90 protocol provides time upto 2000.

In USA, as per the new Clean Air Act amendment, the production of HCFCs would be frozen in the year 2015 and production banned by 2030. Restrictions on the non-refrigeration use of the chemical would begin in 2015 and by 2020 for uses as a refrigerant.

Federal Republic of Germany has announced phase out of HCFC's by 2000. At the same time, some of the Developing countries (Taiwan and China) have commissioned new CFC plants in the last two years. China has plans to expand the capacities in next two years. South Korea has recently commissioned plant for CFC-113.

The developments in the Industrialised countries are pointer to a conclusion that the later a country starts to take regulatory measures, the more difficult the phasing out is going to be.

3.4 Refrigeration and Air Conditioning Sector

Current Uses :

Of the Annex A - Group I substances of the Montreal Protocol (Appendix III of this report), current technologies use CFC-11 and CFC-12 in vapor compression refrigeration equipment and in polyurethane, polyisocynurate, and extruded polystyrene foam insulation. CFC-12 is used as refrigerant in refrigerators, freezers, automobile air conditioners, refrigerated vending machines and food display cases, and a variety of small home and business appliances (e.g., dehumidifiers, water fountains). CFCs 11 and 12 are used as refrigerants in centrifugal chillers for commercial buildings. Plastic insulations made of rigid foam containing CFC-11 or CFC-12 have found broad use in refrigerators, freezers, and water heaters. Extruded foam boards and panels made of similar materials and the same blowing agents are used in residential and commercial buildings because of their low cost and very low thermal conductance.

CFC-113 is used mainly for solvent cleaning of electric equipment, printed circuits, aircraft parts, fine instrumentation, medical instruments and precision glassware. It is not relevant in Refrigeration and Air Conditioning sector.

CFC-114 is used principally in aerosol cosmetics but is also used in small quantities in some foam blowing applications. CFC-115 is used as a refrigerant, mainly in an azeotropic mixture with HCFC-22 (HCFC-502) for low and medium temperature refrigeration applications.

Of Group II substances of Annex A of the Protocol (see Appendix III), there is insignificant consumption of Halon 1301 as refrigerant for very low temperature applications i.e. minus 70°C.

CFCs have played key role in tropical climate and developing economy of India. Food preservation, vaccine preservation, pharmaceutical manufacture are the core development programmes in India where CFCs are of vital importance.

This report deals with CFC-11 and 12 as refrigerants and CFC-11 as blowing agent in domestic and commercial refrigeration applications only. HCFC-22 is considered due to its overlapping uses with CFC-12.

It is recognised that :

(i) CFC-11 and 12 are used in industrial sectors other than Refrigeration and Air Conditioning and any phase out plan will have to take into account the consumption in those sectors also.

(ii) Control measures as stipulated in Article 2 of the Protocol will apply to the calculated level of production and consumption of controlled substances (ODS) of Group I taken together and not separately.

4. CURRENT AND FORECAST OF DEMANDS FOR OZONE DEPLETING SUBSTANCES IN REFRIGERATION AND AIR CONDITIONING SECTOR

It was decided for the purpose of current and future demands to consider the report prepared in 1990 by M/s. S.B. Billimoria & Co. for the Ministry of Environment and Forests as a starting point. The present report is based on extensive field surveys and discussions with manufacturers and users, and experts and AIACRA (All India Air Conditioning and Refrigeration Association) production figures for the period 1986 to 1990.

Refrigeration and Air Conditioning sector covers :

Sector	Products
Appliances	* Refrigerators * Deep Freezers/Ice Cream Cabinets * Bottle Coolers * Water Coolers
Mobile Applications	* Car Air Conditioners * Buses and Vans * Train Air Conditioners * Shipping
Central Plants	* Reciprocating Compressors * Centrifugal-Chillers
Cold Stores	
Ice Candy Machines	
Room Air Conditioners	
Package Air Conditioners	

4.1 Refrigerators

4.1.1 Industry Status

The Refrigerator Industry in India is 30 years old. There are, at present, five manufacturers for refrigerators and four of them have captive facilities for manufacture of compressor, as well. Two other manufacturers, who exclusively manufacture compressors, supply them to the refrigerator industry as well as to the replacement market.

Refrigerators range in capacities from 65L to 380L but the 165L capacity model is most popular accounting for 93% of the market sales in 1990.

Different figures varying between 15 to 20 years are quoted for life expectancy of the refrigerator but, for the purpose of this report, it is taken as 15 years.

Refrigerator is a life time purchase and, very often than not, it is got repaired again and again than replaced by a new model.

The production and total population figures in the industry over the last 5 years is shown in Table 4.1.

TABLE 4.1

PAST AND PRESENT PRODUCTION AND POPULATION DATA (REFRIGERATORS)

('000 Nos.)

Year	Production	Population in Field
1986	592	3808
1987	700	4400
1988	900	5100
1989	988	6000
1990	1237	6988

Note : Scrapping of refrigerators after 15 years of use is not considered in the above figures.

The Installed capacity in 1989 is 14.0 lacs and this figure is expected to rise to 20.5 lacs by 1992 with the existing manufacturers alone. There are two new players expected to come into the market by 1993, with a capacity of 5.0 lacs each.

Letters of intent have been issued for a total manufacture of 130 lacs in all.

4.1.2 Consumption Norms

The controlled substances used are CFC-12 as a 'Refrigerant' both for 'Initial charging' and 'Recharging' and CFC-11 for 'Foam blowing'.

Refrigerant charge for a refrigerator varies from 75 gms to 150 gms depending upon the capacity of the refrigerator but considering that 165L model accounts for more than 90% of the production, it was thought fit to take a weighted average of the charge assuming the total production to be only of 165L model.

Refrigerant charge for a 165L model is typically 135 gms. Allowing a leakage of maximum of 5 gms during charging, a consumption norm of 140 gms for refrigerators was arrived at.

'Recharging' of refrigerators is done either because of rejections in manufacture or because of leaks developed at joints during operation in field or compressor failures. During the 'Warranty period', refrigerators are referred to original manufacturers or their Service Stations for reprocessing and hence recharging wherever necessary. In general, in Post-Warranty period, the customer goes to repair shops in the unorganised sector where facilities do not exist for accurate charging or proper welding of leaked joints. A recharge value of 200 gms per refrigerator was therefore considered appropriate.

CFC-11 is used in refrigerators for polyurethane foam insulation. The average consumption of CFC-11 in a typical 165L refrigerator is about 450 gms.

In earlier models, glass wool was used but there is a gradual shift from glass wool to polyurethane foam which offers advantages in terms of automation and productivity in manufacture. Although glass wool and PUF models exist side by side today, by 1995 to 1997, which is the period of reckoning for the Montreal Protocol limits, it is expected that the total manufacture would shift to foam insulation only. The consumption figures for CFC-11 from 1996 onwards are calculated on this basis.

4.1.3 Growth of Industry and Forecast of Refrigerator Production and Population

The key factors influencing the growth of refrigerator are :

- Growing urban middle class households
- Small family norm
- Women taking gainful employment and contributing to family income
- Need for food storage because of working women
- Competition, hire purchase schemes

The penetration into the urban household in India is to the extent of 10% as against 90 to 100% in developed countries. Substantial scope for growth is seen.

In the rural areas, penetration is taking place into the middle and affluent households of rural farmers but the process is generally slow because of frequent power supply failures, wide voltage fluctuations leading to failure of the machines and lack of service/repair facilities.

The growth in the refrigerator industry has been erratic so far but an average growth of 15% can be forecast upto 2000. Beyond 2000, certain amount of saturation is expected and a reduced growth rate of 10% is assumed.

Table 4.2 gives a forecast of refrigerator production and population upto 2010.

TABLE 4.2

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - REFRIGERATORS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	1240	2860	8080	9770	13010
Population	7100	17950	58400	72294	98086

Note : Refrigerators after 15 years life are assumed scrapped.

4.1.4 Projected Demand for CFCs - 1990 to 2010

The demand for CFC-11 and 12 based on the consumption norms and the production and population figures is given in Table 4.3. The years 1996, 2005, 2007 and 2010 are the 'Bench Mark' years for Protocol implementation.

The table also distinguishes the CFC-12 consumption for 'initial charge' and subsequent 'recharging'.

TABLE 4.3

FORECAST OF DEMAND (UNCONSTRAINED) IN REFRIGERATORS

(Metric Tonnes)

USE	1990		1996		2005		2007		2010	
	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC 12	CFC-11	CFC-12	CFC-11	CFC-12
Refrigerant										
- Initial Charge	-	174.0	-	401.0	-	1132.2	-	1367.8	-	1821.0
- Recharging*	-	94.0	-	236.0	-	838.0	-	1064.0	-	1480.0
Foam Blowing	342.0	-	1290.0	-	3636.0	-	4396.2	-	5854.0	-
SUB TOTAL	342.0	268.0	1290.0	637.0	3636.0	1969.2	4396.2	2431.8	5854.0	3301.0
CFC-11 & 12	610.0		1927.0		5605.0		6828.0		9155.0	

* Recharging includes

1. Recharge during manufacturing and warranty of five years.
2. Recharge of 10% of population of previous fifth year

4.2 Deep Freezers/Ice Cream Cabinets

4.2.1 Industry Status

The Deep Freezer/Ice Cream Cabinets Industry is still in its infancy in India. They are mainly used in hotels, restaurants and meat shops and for storing ice creams. Household usage of deep freezer is very low.

Deep freezers are available in capacities ranging from 85L to 425L.

There are three manufacturers in the organised sector - two of them manufacturing refrigerators also. There is no manufacturer in the organised sector exclusively manufacturing deep freezers.

Because of the advantageous excise duty structure almost 80% of deep freezers/ice cream cabinets are made in the unorganised sector. It has, therefore, become very difficult to get precise figures of production and population.

Based on the AIACRA production figures of the three manufacturers in the organised sector the total production in organised as well as unorganised sector for deep freezers/ice cream cabinets in 1990 is estimated as 8760 Nos. and the population at little over 1,00,000 Nos.

So far, majority of deep freezers are made with glass wool insulation and, in many cases, open type compressors are in use.

There is a trend towards foaming the deep freezers because of the requirements of 'Cold Chain' programmes for reduced energy consumption and increased 'hold over time'. However, the volumes are not attractive enough to introduce automation in manufacture through foaming and conveyor line assemblies.

The requirement of deep freezers alongwith ice cream cabinets is growing steadily at a rate of 10%. This trend is expected to continue till 2000 after which the growth rate may fall to 7%.

Table 4.4 gives the forecast of production and population of deep freezers/ice cream cabinets for the period 1990-2010.

TABLE 4.4

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - DEEP FREEZERS/ICE CREAM CABINETS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	8.76	21.52	45.88	52.54	64.20
Population	101.20	183.70	390.50	440.00	519.00

Note : Deep Freezer/Ice Cream Cabinets assumed scrapped after 10 years life.

4.2.2 Consumption Norms

The initial charge required is assumed at 540 gms which is the average of charge values required for compressors of the three different models. The recharge value is assumed to be 42% more at 770 gms on considerations similar to those existing with refrigerators.

Being a commercial refrigeration product manufactured mostly in unorganised sector, the life expectancy is 10 years. It is assumed that about 10% of the population are recharged each year.

With the advent of ice cream cabinets and energy conservative chest type deep freezers, foaming in a limited way is foreseen. A requirement of 1000 Nos. of such type of deep freezers is projected for 1991. It is assumed that there will be linear growth @ 1000 Nos. per year upto 2000 and 7% beyond that for such type of freezers.

Deep freezer requires a foam thickness larger than that for a refrigerator. In case of 'Energy Conservative' models the thickness can be even more, but considering that such models are in smaller capacities, the foam quantity is approximately same. A typical value of CFC-11 required for the 'Foamed Deep Freezers' is 550 gms.

4.2.3 Projected Demand of CFCs – 1990 to 2010

The projected demand of CFC-11 and 12 for deep freezers/ice cream cabinets is given in Table 4.5. The figures for CFC-12 for charging and recharging are separately indicated.

TABLE 4.5

FORECAST OF DEMAND (UNCONSTRAINED)
- DEEP FREEZERS/ICE CREAM CABINETS

(Metric Tonnes)

SE	1990		1996		2005		2007		2010	
	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC 12	CFC-11	CFC-12	CFC-11	CFC-12
Refrigerant										
- Initial Charge	-	4.73	-	11.62	-	24.78	-	28.37	-	35.00
- Recharging	-	7.80	-	14.10	-	30.00	-	34.00	-	40.00
Foam Blowing	-	-	4.73	-	10.1	-	11.56	-	14.16	-
CFC-11 & 12	12.53		30.45		64.88		73.93		89.16	

4.3 Bottle Coolers

4.3.1 Industry Status

Bottle coolers are available in capacities of 94 - 471 Litres which can store 120-600 bottles of 190 ml respectively. All of these have glasswool for insulation.

Bottle coolers are used mainly in restaurants and shops to store bottled aerated drinks.

Small roadside soft drinks outlets in semi-urban and rural areas use ice boxes in lieu of bottle coolers.

The bottle coolers segment is dominated by the unorganised sector which enjoys around 80% of the total market share presently. The large share commanded by the unorganised sector is due to favourable excise duty structure.

In the organised sector, there are three major manufacturers. The growth in the organised sector has been erratic.

Apart from the captive use of compressors by one of the manufacturers in the organised sector, compressors for this use are also sourced from two major manufacturers of compressors in the organised sector.

With multinationals entering the soft drink business, bottle coolers in the form of visible refrigerated showcases (Visi Coolers) have become the new trend. These models require to be 'Foamed'. The present requirement of Visi Coolers is upto 200 bottles capacity.

For refrigerated show cases, a demand of 1000 Nos. in 1991 is assumed. It is assumed that the demand will increase at a rate of 1000 Nos. each year till 1996. Thereafter the industry growth rates apply.

The past growth rate during 1975-88 has been 19.2%. However, the production during the period 1985-88 has been relatively stagnant.

The growth of the soft drink industry during 1985-88 is placed at 15% by industry sources. However, the other major segment of relevance in the beverages industry, the carbonated soda industry, has shown virtually no growth during 1985-88.

Taking into account the recent trend of stagnation in production, conservative growth rates of 10% and 7% have been applied to this sector for the period 1990-2000 and 2000-2010 respectively.

Table 4.6 gives the forecast of the production and population figures of bottle coolers for the period 1990 - 2010.

TABLE 4.6

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) IN BOTTLE COOLERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Bottle Coolers					
- Production	5.0	8.8	18.0	20.7	25.4
- Population	41.00	79.5	157.0	176.0	207.0
Visi Cooler					
- Production	--	6.00	12.3	14.1	17.2
- Population	--	15.00	78.4	91.3	112.5

Note : Bottle Cooler/Visi Cooler assumed scrapped after 10 years.

4.3.2 Consumption Norms

CFC-12 is used as the refrigerant in Bottle Coolers and Visi Coolers. Taking a weighted average of production in various sizes, the initial charge is taken as 230 gms and recharge value at 330 gms. The life expectancy of this product is 10 years. As it is a commercial product, manufactured mostly in unorganised sector, it is assumed that 20% of the population will be recharged each year.

CFC-11 requirement in foamed bottle coolers/visi coolers is 600 gms approximately.

4.3.3 Projected Demand of CFCs - 1990 to 2010

The projected demand of CFC-11 and 12 for bottle coolers/visi coolers is given in Table 4.7. The figures for charging and recharging are indicated separately.

TABLE 4.7

FORECAST OF DEMAND (UNCONSTRAINED) IN BOTTLE COOLERS

(Metric Tonnes)

USE	1990		1996		2005		2007		2010	
	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12
Refrigerant										
- Initial Charge	-	1.15	-	3.40	-	6.94	-	8.00	-	10.00
- Recharging	-	2.70	-	6.58	-	15.40	-	17.60	-	21.00
Foam Blowing	-	-	9.00	-	18.00	-	21.00	-	26.00	-
CFC-11 & 12	3.85		18.98		40.34		46.60		57.00	

4.4 Water Coolers

4.4.1 Industry Status

Water Coolers are commercially available in two distinct types - 'Cooling' and 'Storage'. The capacities vary from 15 litres to 150 litres/hour for the 'Cooling' model while the capacity of 'Storage' model varies from 30 litres to 380 litres.

There are five major manufacturers in the organised sector, with a total capacity over 25,000 nos. per annum and they account for 95% of the market share. In 1990, 20245 Nos. were manufactured.

The consumers for water coolers are 'Commercial' or 'Institutional' in nature, such as offices, factories, restaurants, hotels, hospitals, schools and colleges. The compounded average rate of growth (CARG) between

1975-88 has been 7 per cent. However, the growth rate in the future is likely to be higher than 7 per cent because of the following reasons.

- the overall industrial growth rate has been higher at 8-9% in the Seventh Plan (1985-89) compared to previous plan periods.
- excise duty on water coolers has been withdrawn from the fiscal year 1986-87.
- the use of water coolers in factories has been made compulsory under the Factories Act.

A growth rate of 10% for the period 1990-2000 and 7% for the period of 2000-2010 are assumed.

The future production and population estimates for water coolers for 1990 to 2010 are given in Table 4.8.

TABLE 4.8

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - WATER COOLERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	20.24	35.80	73.60	84.20	103.20
Population	161.00	316.00	628.00	707.00	834.00

Note : Water Coolers assumed scrapped after 10 years.

4.4.2 Consumption Norms

Both CFC-12 and HCFC-22 are used as refrigerants. The smaller water coolers (upto 40 litres per hour cooling capacity) use CFC-12 whereas the larger water coolers (60 litres per hour and above) use HCFC-22.

The life expectancy of a water cooler is 10 years and almost 20% are charged each year.

As water coolers of widely different capacities are manufactured, and also sold in different quantities, a weighted mean average value for charging and recharging are calculated. These are -

Initial charge	415 gms
Recharge	550 gms

4.4.3 Projected Demand of CFCs - 1990 to 2010

Table 4.9 gives the projected demand of the refrigerant based on the above consumption norms. 50% is assumed to be CFC-12 and the balance HCFC-22. The figures for charging and recharging are separately indicated.

TABLE 4.9

FORECAST OF DEMAND (UNCONSTRAINED) IN WATER COOLERS

(Metric Tonnes)

USE	1990		1996		2005		2007		2010	
	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22
Initial Charge	4.2	4.2	7.43	7.43	15.3	15.3	17.5	17.5	21.4	21.4
Recharging	8.86	8.86	17.44	17.44	34.5	34.5	39.0	39.0	46.0	46.0
TOTAL	13.06	13.06	25.00	25.00	49.8	49.8	56.5	56.5	67.4	67.4

4.5 Car Air Conditioners

4.5.1 Industry Status

Manufacturing of car air conditioners in India, in a very limited way, started in 1984. At present, there are two manufacturers of car airconditioners in the organised sector, both of them set up with technology from abroad. A third manufacturer has also recently emerged based on completely indigenous technology. Substantial number of car air conditioners are brought into the country through imported cars and also smuggling of car airconditioners.

The production and imports of car airconditioners in 1989, is estimated at 90,000 Nos. The total population is put at 2,14,000 Nos. The future demand for car air conditioners would arise from two sources :

- OEM fittings i. ., new cars produced with air conditioners
- fittings on old cars.

Discussions with manufacturers of cars and car air conditioners indicate that production of new cars will grow at the rate of 7% per year and 15% of them are assumed to be with air conditioners at present, but this percentages is expected to grow in future. Also 3 to 4% of the cars in field will be retrofitted with Air Conditioners.

Based on these considerations car ACs are assumed to grow at the rate of 10% till 2010.

The production and population figures for the period 1990 to 2010 are given in Table 4.10.

TABLE 4.10

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - CAR AIR CONDITIONERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	99.0	175.0	413.5	500.0	666.0
Population	304.0	1064.0	2683.0	3182.0	4136.0

Note : Car A/C assumed scrapped after 10 years life.

4.5.2 Consumption Norms

CFC-12 is used as the refrigerant. The initial charge required is 700 gms and for recharge 1000 gms has been assumed.

The life expectancy is 10 years. 33% CACs are assumed to be recharged every year.

4.5.3 Projected Demand of CFCs - 1990 to 2010

The projected demand of CFC-12 on account of Car air conditioners for the period of 1990 to 2010 is given in Table 4.11. Figures for initial charging and recharging are shown separately.

TABLE 4.11

FORECAST OF DEMAND (UNCONSTRAINED) IN CAR AIR CONDITIONERS

(Metric Tonnes)

CFC-12	1990	1996	2005	2007	2010
Initial Charge	69	122	289	350	466
Recharging	100	351	885	1050	1365

4.6 Bus and Van Air Conditioning

4.6.1 Industry Status

Air conditioning and refrigeration systems in buses and vans started in early eighties. There are three manufacturers in the organised sector, who build these systems with imported compressors. Few units in the unorganised sector also assemble these systems.

It is estimated that the production and population figures for 1990 are 350 Nos. and 2770 Nos. respectively.

This sector is growing rapidly side by side with growth in tourism, dairy and marine product industries. A growth rate of 15% is considered a reasonable assumption.

Table 4.12 gives the forecast of production and population figures for the period 1990-2010.

TABLE 4.12

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - BUS & VAN AIR CONDITIONERS

('000 Nos.

Parameter	1990	1996	2005	2007	2010
Production	0.35	0.81	2.85	3.80	5.73
Population	2.77	6.00	16.40	20.80	30.20

Note : Bus & Van A/C assumed scrapped after 10 years.

4.6.2 Consumption Norms

Each bus or van is assumed to have 7-8 TR capacity. Accordingly the value of charge is 10 kg. The recharging figure is taken more at 12 kg. CFC-12 is the refrigerant.

Because of the near continuous use of the buses and vans and poor road conditions, the life expectancy of the AC equipment is taken as 10 years. It is also assumed that 50% of the units get recharged every year.

4.6.3 Projected Demand of CFCs - 1990 to 2010

The projected demand of CFC-12 on account of initial charging and recharging is given in Table 4.13.

TABLE 4.13

FORECAST OF DEMAND (UNCONSTRAINED)
IN BUS & VAN AIR CONDITIONERS

(Metric Tonnes)

CFC-12	1990	1996	2005	2007	2010
- Initial Charge	3.50	8.10	28.50	38.00	57.30
- Recharging	16.62	36.00	98.00	125.00	181.00

Train Air Conditioning

4.7.1 Industry Status

Air conditioned coaches are manufactured by ICF, Madras and Kapurthala. The compressors are of the open type and are supplied by three manufacturers in the organised sector. Each coach requires two compressors.

Railways have been manufacturing 100 coaches every year upto 1990. The total population of the AC coaches in India is estimated at 800 Nos. in 1990.

Railways have no plans on the anvil to increase the production rate above what they are manufacturing. It is, however, assumed that 150 coaches per year will be made during 1998 to 2003 and 200 coaches per year beyond 2003.

The forecast of production and population figures of AC coaches for 1990 to 2010 is given in Table 4.14.

TABLE 4.14

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - TRAIN AIR CONDITIONERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	0.10	0.10	0.20	0.20	0.20
Population	0.80	1.40	2.80	3.20	3.75

4.7.2 Consumption Norms

CFC-12 is the refrigerant used. The initial charge required per coach is 36 kg. For recharging which is more in the nature of 'topping up' 32 kg is used. It is assumed that every compressor is charged atleast once each year.

4.7.3 Projected Demand for CFCs - 1990 to 2010

Table 4.15 gives the projected demand of CFC-12 for the period 1990 to 2010 on account of initial charging and recharging.

TABLE 4.15

FORECAST OF DEMAND (UNCONSTRAINED) IN TRAIN AIR CONDITIONING

(Metric Tonnes)

CFC-12	1990	1996	2005	2007	2010
- Initial Charge	3.6	3.6	7.2	7.2	7.2
- Recharging	25.6	44.8	89.6	102.4	120.0

Central Plants

Central plants are based on one of the two types of refrigeration systems - vapour absorption system and vapour compression system.

Vapour absorption systems use ammonia and water or lithum bromide and water as refrigerants. Vapour compression systems use CFC-12, HCFC-22 and ammonia as refrigerants.

This report considers only those plants which are based on CFC-12 or HCFC-22.

In Central plants three types of compressors are commonly used - reciprocating, centrifugal and screw type.

Reciprocating and Screw type compressors are generally designed to accept one or more of the refrigerants CFC-12, HCFC-22 and ammonia. Usually the design is based on HCFC-22 and it can be used with CFC-12 with a slight reduction in capacity for low temperature applications.

In centrifugal compressors, CFC-11 & 12 are the most commonly used refrigerants and, because of higher specific volume and velocity of refrigerant, this compressor is of smaller size compared to other types and is preferred where space is at a premium.

The central plants (using CFC-12, HCFC-22 and CFC-11) as well as compressors used in these plants are mainly manufactured in the organised sector. Four companies make central plants and compressors, while two others manufacture compressors only and feed the other manufacturers and the replacement market.

The growth rate during 1985-89 has been 13.8%.

4.8.1 Consumption Norms

Reciprocating compressors cover upto 200 TR and the common size is 100 TR. For a 100 TR reciprocating compressor the initial charging required is 110 kg. The complete recharging of these machines is rare except in the event of major breakdown. To compensate for the leaks, 'Topping' up of refrigerant is done often. The 'topping up recharge' can be assumed to be 40% of the initial charge (44 kg each for CFC-12 & HCFC-22).

Centrifugal compressors go beyond upto 600 TR in India and they use CFC-11 as the refrigerant. A weighted average size of the compressor is 400 TR. 25 to 30 Nos. of centrifugal chillers with CFC-12 with CFC-12 are manufactured in 1990. A population of 150 such units is assumed in he year 1990.

The consumption of CFC-11 in centrifugal compressor of 400 TR is 600 kg. An average of 40% of initial charge can be assumed for the topping up charge, per ton of refrigeration each year in this case also.

Table 4.16 and 4.17 give the consumption figures of these refrigerants in the last few years.

TABLE 4.16

PAST CONSUMPTION OF CFC-12 AND HCFC-22 IN RECIPROCATING SYSTEMS

(Metric Tonnes)

USE	1985		1986		1987		1988		1989	
	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22
Initial Charge	14	164	13	156	16	198	18	218	22	260
Recharging	112	772	120	834	129	894	140	969	152	1051
TOTAL	126	936	133	990	145	1092	158	1187	174	1311

TABLE 4.17

PAST CONSUMPTION OF CFC-11 & CFC-12 IN CENTRIFUGAL PLANTS

(Metric Tonnes)

USE	1987		1988		1989	
	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12
Initial Charge	28	--	32	--	38	--
Recharging	107	--	118	--	131	--
TOTAL	135		150		169	

Note : CFC-12 figures are not available.

4.8.2 Future Growth of Central Plants

The major factors influencing growth are :

- growth in the building sector
- growth in end-use industries especially
    - drugs, pharmaceutical & chemicals
    - synthetic fibres
    - food processing
    - electronics
- government policy with respect to imports and excise duty
    - imports are not allowed except for use in 100% export oriented units, hospitals, etc.
    - excise duty is 60% ad valorem.

The future growth in central plants till the year 2010 has been estimated on the basis of growth in various end use sectors weighted by the installation of central plants in each of these end use sectors as shown in Table 4.18.

TABLE 4.18

PAST WEIGHTED AVERAGE GROWTH OF CENTRAL PLANTS

Sector	Proportion of Central Plants Installed %	Sector Growth Rate (%) (1985-88)
Drugs, Pharmaceuticals & Chemicals	33.8	11.3
Synthetic Fibres	11.3	12.0
Food Processing	5.0	7.6
Electronics	5.0	36.4
Buildings	44.9	14.3
TOTAL	100.0	13.8 (weighted average)

Table 4.19 provides the estimates of the future production and population of central plants has with this growth rate.

TABLE 4.19

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - CENTRAL PLANTS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Reciprocating					
- Production	2.96	6.4	20.5	26.6	39.0
- Population	30.10	55.0	149.83	194.03	256.0
Centrifugal					
- Production	0.09	0.19	0.60	0.78	1.16
- Population	0.62	1.37	4.17	5.59	8.22

4.8.3 Demand for CFC's & HCFC's

The demand for CFC-12, HCFC-22 & CFC-11 in central plants is shown in Table 4.20.

TABLE 4.20

FORECAST OF DEMAND FOR CFC-12, HCFC-22 & CFC-11 (UNCONSTRAINED)
IN CENTRAL PLANTS

(Metric Tonnes)

USE	1990		1996		2005		2007		2010	
	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22
Reciprocating Systems										
Initial Charge	25	301	54	650	171	2079	222	2704	326	3964
Recharging	166	1158	327	2093	905	5687	1135	7402	1594	9683
TOTAL	191	1459	381	2743	1076	7766	1357	10106	1920	13647
	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12	CFC-11	CFC-12
Centrifugal Systems										
Initial Charge	42	15	84	30	264	96	342	126	510	186
Recharging	113	36	245	84	725	276	984	358	1445	528

.9 Cold Stores

4.9.1 Industry Status

The manufacture of cold storage plants in the country started around mid sixties and has been growing at a rate of 12%. In proportion to the total cold storage capacity, only 5% is based on CFC-12. The balance capacity uses ammonia.

There are two manufacturers in the organised sector for cold stores using CFC-12.

4.9.2 Consumption of CFC's

CFC-12 is used as the refrigerant.

The consumption of CFC-12 in initial charge as well as recharging is shown as per Table 4.21 below :

TABLE 4.21

PAST CONSUMPTION OF CFC-12 IN COLD STORES

(Metric Tonnes)

USE	1985	1986	1987	1988	1989
Initial Charge	12	14	15	17	19
Recharging	15	19	22	26	30
TOTAL	27	33	37	43	49

4.9.3 Forecast of Demand of Cold Stores

The growth of cold stores using CFC-12 depends on

- past growth in cold store installations (i.e. 12% compounded per annum)
- past growth in major user sector such as marine products
- the growth in marine products has been 11% per annum during the eighties.

A growth of 12% per annum (on a compound basis) has been adopted for the future (till the year 2010). On this basis the production and population figures of cold stores (using CFC-12) is forecast as shown in Table 4.22.

TABLE 4.22

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - COLD STORES

Parameter	1990	1996	2005	2007	2010
Production	1973	3896	10805	13554	19042
Population	12534	27759	85038	107828	153961

4.9.4 Demand for CFCs

Average Tonnage of a cold storage unit has been taken as 10 TR. The initial charge is taken as 1.1 kg/TR & Recharge a 1.37 kg/TR. The demand for CFC-12 is shown in Table 4.23.

TABLE 4.23

FORECAST OF DEMAND FOR CFC-12 (UNCONSTRAINED) IN COLD STORES

(Metric Tonnes)

USE	1990	1996	2005	2007	2010
Initial Charge	21	43	119	149	209
Recharging	34	76	233	295	421
TOTAL	55	119	352	444	630

I.10 Ice Candy Machines

Manufacturing is in the hands of a few units in the unorganised sector. In North India, the bulk of the production is accounted by 5 such units. At least a third of the production is in the north.

Detailed information on this sector was not available since this sector consists of unorganised units spread out all over the country. They are mostly used in semi urban areas, town and large taluk headquarters.

The production of these machines in 1990 was estimated at 6959 numbers. Past and present growth in production has been very low.

The population of these units is approximately 1 lakh in the year 1990.

4.10.1 Consumption of ODS

CFC-12 is used as the refrigerant.

The consumption norms are 10 kg for initial charge and 10 kg for recharging. It is assumed that 50% of the units in operation are recharged each year.

4.10.2 Forecast of Growth of the Industry

The growth in these machines is linked to the growth in population of rural and semi-urban areas (assuming that there is no major shift in favour or against ice candy in these areas).

The future growth has been assumed to be 2.5% till 2010, slightly higher than the growth expected in the overall population i.e. 2% per annum. This is as per discussions with the manufacturers and dealers.

On the basis of a growth of 2.5% per annum the future production, population of these machines and CFC-12 consumption in initial charge and recharging is calculated and shown in Table 4.24 and Table 4.25 respectively.

TABLE 4.24

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - ICE CANDY MACHINES

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	6.95	8.07	10.07	10.57	11.40
Population	96.45	113.25	150.00	156.00	165.46

TABLE 4.25

FORECAST OF DEMAND (UNCONSTRAINED) IN ICE CANDY MACHINES

(Metric Tonnes)

CFC-12	1990	1996	2005	2007	2010
Initial Charge	69.5	81	101	106	114
Recharging	482.0	566	750	780	827

.11 Room Air Conditioners (RACs) (Window Type and Split Units)

4.11.1 Industry Status

Manufacturing of RACs started in the organised sector during the period 1955-60. There are 5 large manufacturing units in this sector.

The production in the unorganised sector commenced in a significant manner around the mid-seventies. Since then it has rapidly increased in relation to the organised sector, mainly because of advantageous excise duty structure which makes them cheaper. Almost 70% of the RACs are now made in this sector.

Hermetically sealed compressors required for RACs are made by only 3 companies in the organised sector. These companies supply compressors to the whole industry. Technology for compressors is relatively sophisticated and has been imported by all the three manufacturers.

The standard models are 1, 1.2, 1.5, 2 and 3 T in window type and 1.5, 2 and 3T in the split type. The most important segment by sales volume is the window type 1.5 TR units for household as well as institutional and commercial use.

The AIACRA figures of production from organised sector for 1989 and 1990 are 36000 and 40000 nos. respectively.

The figures from unorganised sector are not available readily to predict future trends with any degree of certainty. It is, however, known that the production of this sector is stagnating at 0.8 lakhs per year for the last few years. The population of RACs in 1990 is assumed as 12 lakhs.

5% growth rate is considered reasonable for the period 1990 to 2010.

The estimates of production and population figures for the period 1990 to 2010 are given in Table 4.26.

TABLE 4.26

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - ROOM AIR CONDITIONERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	120	161	250	275	319
Population	1200	2015	2970	3152	3460

Note : Room A/Cs assumed scrapped after 10 years.

4.11.2 Consumption Norms

HCFC-22 is the commonly used refrigerant except in very small units below 1T which are based on CFC-12, but their number is small.

Although most compressors specify HCFC-22 as a system fluid, they can work on CFC-12 with slightly reduced efficiency.

The HCFC-22 charge value for 1.5 T RAC is 1000 gms and this is assumed as the weighted average for the total production. 77% of production is assumed to be used on HCFC-22 and the remaining 23% based on CFC-12.

For recharging, a value of 1400 gms is assumed, on the basis of considerations similar to those with refrigerators.

Failure of RAC compressors is more frequent than Refrigerators. It is assumed that 20% of the population are recharged each year and the life expectancy is 10 years.

4.11.3 Forecast of CFC Consumption - 1990 to 2010

The consumption of HCFC-22 in initial charging and recharging and CFC-12 in recharging is given in Table 4.27.

TABLE 4.27

FORECAST OF DEMAND FOR CFCs (UNCONSTRAINED)
IN ROOM AIR CONDITIONERS

(Metric Tonnes)

USE	1990		1996		2005		2007		2010	
	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12	HCFC-22	CFC-12
Initial Charge	92	28	126	36	192	58	212	63	245	74
Recharge	258	77	434	130	641	191	680	203	746	223

2 Package Air Conditioners (PACs)

4.12.1 Industry Status

Production of PACs in the country started in 1967 and in terms of absolute numbers, it has always been very low. Bulk of the production is accounted for by 4 manufacturers in the organised sector. Technology has been imported by most of the companies. The range of capacities for PACs vary from 3 to 10 TR.

The AIACRA production figures for 1990 is 4400 Nos. The population in 1990 is estimated as 21,000 Nos.

A growth of 12% per annum for the future is assumed on the ground that the small commercial sector is the main customer for such equipment. This sector is growing faster than the overall industrial sector whose growth is expected to be 8% in the long term.

The production and population estimates for the period 1990 to 2010 are shown in Table 4.28.

TABLE 4.28

FORECAST OF PRODUCTION AND POPULATION (UNCONSTRAINED) - PACKAGE AIR CONDITIONERS

('000 Nos.)

Parameter	1990	1996	2005	2007	2010
Production	4.4	9	24	30	42
Population	21	44	122	154	216

4.12.2 Demand for HCFC-22

HCFC-22 is not a controlled substance. An estimate of the demand is however made to assess the capacity available should the CFCs in any application be replaced by HCFC-22.

Table 4.29 shows the demand figures for 1990-2010.

TABLE 4.29

FORECAST OF DEMAND (UNCONSTRAINED) IN PACKAGE AIR CONDITIONERS

(Metric Tonnes)

HCFC-22	1990	1996	2005	2007	2010
Initial Charge	45	89	247	311	436
Recharging	22	47	127	161	226
TOTAL	67	136	374	472	662

4.13 Others

There are other sectors like, Shipping, Navy etc. which have refrigeration and A/C systems aboard. They use both CFC-12 & HCFC-22 as refrigerants. Precise consumption figures are not known but from the enquiries received by the CFC manufacturers, the consumption is around 160 tonnes of CFC-12. The consumption figures for HCFC-22 are as indicated in Table 4.30.

TABLE 4.30

FORECAST OF DEMAND FOR CFC-12 AND HCFC-22 (UNCONSTRAINED) IN OTHER SEGMENTS

(Metric Tonnes)

REFRIGERANT	1990	1996	2005	2007	2010
CFC-12	160	--	--	--	--
HCFC-22	243	356	486	516	564

4.14 Summary of Figures of Consumption of CFC-11, 12 and HCFC-22 in Refrigeration and Air Conditioning Sector

Summary of figures of consumption of CFC-11, 12 & HCFC-22 is indicated in Table 4.31.

TABLE 4.31

SUMMARY OF FORECAST OF DEMAND CONSUMPTION OF CFC-11,12 & HCFC-22

(Metric Tonnes)

USE	1990			1996			2005			2007			2010		
	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22
Refrigerator	342	268	--	1290.0	637	--	3636	1969	--	4396	24[illegible]	--	5854	3301	--
Deep Freezer/ Ice Cream Cabinet	--	13	--	5	26	--	10	55	--	12	62	--	14	75	--
Bottle Cooler/ Visi Cooler	--	4	--	9	10	--	18	22	--	21	26	--	26	31	--
Water Cooler	--	13	13	--	25	25	--	50	50	--	57	57	--	67	67
Car AC	--	169	--	--	473	--	--	1174	--	--	1400	--	--	1831	--
Bus & Van AC	--	20	--	--	44	--	--	126	--	--	163	--	--	238	--
Train AC	--	29	--	--	48	--	--	97	--	--	110	--	--	127	
Central AC Plant	155	242	1459	329	495	2743	989	1448	7766	1326	1841	10106	1955	2634	13647
Cold Store	--	55	--	--	119	--	--	352	--	--	444	--	--	630	--
Ice Candy M/c	--	552	--	--	647	--	--	851	--	--	886	--	--	941	--
Room AC	--	105	350	--	166	560	--	249	833	--	266	892	--	297	991
Packaged AC	--	--	67	--	--	136	--	--	374	--	--	472	--	--	662
Others (Navy & Shipping)	--	160	243	--	--	356	--	--	486	--	--	516	--	--	564
TOTAL	497	1630	2132	1633.0	2690	3820	4653	6393	9509	5755	7687	12043	7849	10172	15931

PRODUCTION CAPACITY OF CFCs AND HCFC-22

CFCs and HCFC-22

The CFCs presently manufactured in the country are CFC-11 and FC-12 while the only HCFC manufactured is HCFC-22. The first large plant for manufacturing these chemicals was set up in 1969. Presently there are 5 manufacturers of these chemicals.

Substantial new capacity has been added in 1988 and 1989. The present licenced/installed capacity is 18700 metric tonnes. The past trend in production capacity, production and capacity utilisation is indicated in Table 5.1.

TABLE 5.1

PAST TRENDS IN CAPACITY & PRODUCTION OF CFC's & HCFC's

(Metric Tonnes)

PARAMETER	1986	1987	1988	1989	1990
PRODUCTION					
- CFC 11 & 12	2421	2718	3401	3600	4041
- HCFC-22	1381	1620	1843	3041	2000
- TOTAL	3802	4338	5244	6641	6041
INSTALLED CAPACITY (11, 12 & 22)	6700	6700	9200	13700	18700
CAPACITY UTILISATION (%)	57	65	57	48	32

All the CFC plants have the capacity for manufacturing HCFC-22. In all of them the production can be switched from CFCs (11 and 12) to HCFC-22 within the same plant.

The present capacity mix of 18700 metric tonnes is as shown in Table 5.2.

TABLE 5.2

PRESENT CAPACITY MIX FOR CFCs/HCFC-22

(Metric Tonnes)

LEVEL OF PRODUCTION CFC/HCFC	MINIMUM	MAXIMUM
CFC - 11	1725	8650
CFC - 12	4075	11050
HCFC - 22	3400	14200

The overall capacity of 18700 metric tonnes cannot be exceeded.

The actual capacity in the industry is larger than the name plate capacity. At least one of the manufacturers can increase his capacity substantially through minor debottlenecking. After 'debottlenecking' by this manufacturer, the total industry capacity would increase to 20200 metric tonnes while the capacity mix would be as shown in Table 5.3

TABLE 5.3

FUTURE CAPACITY CONSTRAINTS

(Metric Tonnes)

	MINIMUM	MAXIMUM
CFC - 11	1725	14100
CFC - 12	4075	16300
HCFC - 22	3400	15700
OVERALL CAPACITY	20,200	

The overall capacity cannot be exceeded.

From the above limits in capacity, it is evident that, even if in some of the Refrigeration products CFC-12 is replaced by HCFC-22, there is adequate capacity to meet the requirements of the industry.

6. SUBSTITUTES AND AVAILABILITY

In reference to the Refrigeration and Air Conditioning Industry, compliance with the Protocol would require India to phase out the use of CFCs over the next twenty years. This requires substitutes or alternative products for each application to be available in India.

It is pertinent to visualise the part played by CFC-11 and 12 in Refrigeration & Air Conditioning Industry to appreciate as to the enormous implications of substitution.

CFC-12 and 11 are both used as refrigerants and any substitute refrigerant must have 'prima facie', comparable refrigerant characteristics, otherwise the design of the compressor, condenser and evaporator system will change. The change can be a modification of the existing design or a development of a totally new design.

New refrigerant should not have damaging effects on copper, aluminium, steel and the epoxy or enamel coatings over the product life. A compatible lubricant has to be found.

The refrigeration systems will have to be redesigned and rebalanced to give the presently attainable efficiencies and energy consumption. Toolings will have to be developed and production practices have to be established taking into account the flammability and/or toxic characteristics.

CFC-11 is also used as the blowing agent for the polyurethane foam insulation and any substitute will have to offer same or similar thermal conductivities for insulation. The compatability of the substitute blowing agent with the plastic liner, aluminium, steel and copper will have to be established. Alternatively new plastics/materials that can withstand the corrosive effect of the new blowing agent, have to be developed.

The toxicity of the new blowing agent will decide the handling practices while the flammability will affect the foaming equipment and procedures. If the thermal conductivity is different, the dimensions of the refrigerator will change with all consequences that follow especially in tooling.

In general, the process of finding a suitable replacement for an existing CFC is long drawn. After a substitute is identified, based on matching or near matching physical and chemical properties, substantial toxicity and flammability tests must be taken up and completed before the equipment manufacturers are able to begin work on laboratory testing to prove performance, energy and lubrication characteristics. Field tests must then be scheduled to verify performance under actual operating conditions. 'Drop in' substitutes are difficult. Therefore, a change in design which lead to change in tools, manufacturing processes and in some cases compatible new materials may be required.

The total process of substitution based on one substitute may take as long as 6 to 8 years. Even after this, the new product can be produced only if the CFC substitute is available in commercial quantities and at reasonable price.

Although a number of substitutes are being proposed, there are several uncertainties.

Firstly there is a genuine apprehension that what is regarded as a substitute today may not be environmentally acceptable tomorrow. For instance, there is a move to phase-down HCFCs because their ODP, even though less compared to CFCs, is still considered unacceptable on a long term basis. Some Scandenavian countries and Germany, who are signatories to Montreal Protocol, have announced plans to phase out HCFCs in those countries by year 2000.

Secondly Greenhouse Warming Potential (GWP) may become another parameter to assess and decide CFC substitutes. Whether this will be so or not will depend on the deliberations of the 'Parties' at the next review meeting.

Thirdly the efforts to establish Ozone friendly substitutes are driven by major chemical companies in the Developed countries. These companies are concerned not only in finding a reliable, safe and cost effective substitute but also in expanding their business through proprietory technologies.

Taking all the above requirements, implications and uncertainties into account, a list of various promising substitutes for the CFCs used in this industry is given in Table 6.1. An appraisal of these substitutes with their merits and demerits for each application category is given in the following subsections.

TABLE 6.1

PROMISING CFC SUBSTITUTES

Product	Present	Promising Alternatives/ Substitutes
1. Refrigerator	CFC-12 (Refrigerant)	HFC-134a, HFC-152a, HCFC-22 Azeotropic & Non-azeotropic mixtures
	CFC-11 (Foam Blowing)	HCFC-123, HFC-141b
2. Deep Freezer	CFC-12 (Refrigerant)	HFC-134a, HFC-152a, HCFC-22 Azeotropic & Non-azeotropic mixtures
	CFC-11 (Foam Blowing)	HCFC-123, HFC-141b
3. Bottle Cooler	CFC-12 (Refrigerant)	HFC-134a, HFC-152a, HCFC-22 Azeotropic & Non-azeotropic mixtures
	CFC-11 (Foam Blowing)	HCFC-123, HFC-141b
4. Water Cooler	CFC-12 (Refrigerant)	HFC-134a, HFC-152a, HCFC-22
	HCFC-22 (Refrigerant)	No change
5. Car A/C	CFC-12 (Refrigerant)	HFC-134a
6. Bus & Van A/C	CFC-12 (Refrigerant)	HFC-134a
7. Train A/C	CFC-12 (Refrigerant)	HFC-134a
8. Central A/C	HCFC-22 (Refrigerant)	No change
	CFC-11 (Refrigerant)	HCFC-123, HFC-141b
	CFC-12 (Refrigerant)	HFC-134a
	Ammonia (Refrigerant)	No change
9. Cold Store	HCFC-22 (Refrigerant)	No change
	CFC-12 (Refrigerant)	HFC-134a
	Ammonia (Refrigerant)	No change
10. Ice Candy M/c	CFC-12 (Refrigerant)	HCFC-22
11. Room A/C	HCFC-22 (Refrigerant)	No change
	CFC-12 (Refrigerant)	HCFC-22
12. Packaged A/C	HCFC-22 (Refrigerant)	No change
13. Shipping	HCFC-22 (Refrigerant)	No change
	CFC-12 (Refrigerant)	HCFC-22

6.1 Domestic Refrigerators

In a domestic refrigerator the cost of the refrigerant is only 0.38% of cost of the refrigerator. Refrigerators are made in large numbers and require considerable amount of tooling and automation for mass production. The choice will fall on such substitute which gives comparable physical and thermodynamic characteristics, but which will not require major changes of toolings and production processes.

It is also to be appreciated that Refrigerators, Deep Freezers may also have to exported and this means that the widely accepted substitute worldwide will have to be used in these products from the point of view of serviceability.

For domestic refrigerators HFC-134a, HFC-152a and HCFC-22 and azeotropic mixtures are the possible substitutes but each of them have their merits and demerits.

6.1.1 Single Component Refrigerant System

HFC-134a

HFC-134a is widely regarded by the Refrigerator industry as the likely alternative. It has zero 'ODP', a GWP of 0.26, a boiling point very close to CFC-12 and assures discharge and suction pressures similar to those using CFC-12. Suitable Polyglycols and esters are available as compatible lubricants. Tests have shown that if HFC-134a and polyglycol lubrication system is used as 'drop in' substitute in a CFC-12 compressor, the power consumption increases by around 8%. Tests on Chest type Deep freezer showed the performance is better with HFC-134a. (See "Refrigerator freezer energy testing with Alternate Refrigerants", by Vinyard, E.A., Sand, J.R. and Mitter, W.A. ASHRAE Transactions, Vol.95, Part 2, 1989)

Even if there is an energy penalty, it is a considered opinion that a redesign of one of the components which does not require costly tooling can overcome this problem. (See "Experimental investigations in Domestic Refrigerators - Freezers with HFC-134a" by Kawamoto,A. and Kojima, T.A., ASHRAE, Asia Pacific Conference, Singapore, May 1991)

HFC-134a has a compatability with motor insulation, anaerobic adhesives, elastomers, and the molecular sieves (used in driers) comparable to that with CFC-12 and vastly superior to HCFC-22.

The drawback for HFC-134a at this point of time seems to be that, although the initial toxicity test results have been favourable, the PAFT test has not yet been completed and the result will be known only in 1992.

The other problem, though minor, is its poor response to the electronic leak detection being used at present.

In an international scenario HFC-134a is regarded as the only alternative in Europe and one of the promising alternatives in USA and Japan. However GWP related issues associated with this substitute may come up later.

According to the literature, a large number of refrigerator compressor manufacturers are in advanced stage of manufacturing of compressors with HFC-134a. A list of such manufacturers is in Appendix V.

Several chemical manufacturers abroad are establishing production facilities for HFC-134a and some of them have announced the dates for commercial availability of HFC-134a. The list is given in Appendix VI.

In India, one of the CFC manufacturers is able to provide samples of HFC-134a for tests by refrigerator manufacturers.

The manufacturing process for HFC-134a evolves more than one step.

HFC 152a

It has zero ODP and low GWP (0.03), a boiling point very close to CFC-12 and assume a lower suction pressure, and a discharge pressure of the same order as those using CFC-12. An increase in efficiency is indicated without a redesign of the equipment. Also because of higher latent heat, a lower refrigerant quantity will be required. It is also non-toxic.

However, this refrigerant is flammable and will require for its use an amendment of existing flammability standards, a critical consideration of the logistics and consumer safety concerns and additional investments in the manufacturing line for fire safety.

HFC 152a is, nevertheless, an established product with one step process for its manufacture.

This refrigerant is considered as one of the alternatives for domestic refrigerator in China and USA.

HCFC-22

It has an ODP of 0.05 and GWP of 0.34 but a boiling point much lower than that of CFC-12. Under the conditions imposed by refrigerator specifications, HCFC-22 will have to be operated at higher discharge and suction pressures. The swept volume is less that of CFC-12 but the bore diameter will be more and the stroke less. The clearance space is very small - a feature which requires very accurate machining of piston and cylinder heads and this is not compatible with mass manufacturing operations. Moreover the high discharge pressure will necessitate cooling of the motor windings which calls for an exclusive compressor design. Because of high condensing temperature, forced air cooling condenser will be required.

A major obstacle to the use of HCFC-22 as the refrigerant in refrigerators is the electro deposition of copper & copper salt on the internal surfaces of the capillary and on compressor and motor bearing surfaces. Deposition of these materials causes partial restriction of the capillary and resultant malfunction of the system.

The compatability of HCFC-22 with motor insulation, anaerobic adhesives, elastomers and 4A molecular sieves as desiccant is inferior to that with CFC-12. It is known that the average life of Room A/C, Water Cooler etc. which uses HCFC-22 is around 10 years.

With some of the European countries already planning to phase out HCFC-22 by 2000, investment on production facilities based on HCFC-22 is regarded as a financial risk.

HCFC-22 is indigenously available.

Azeotropic Mixtures

CFC-500 (73% CFC-12, 27% CFC-152a) or CFC-12/DME (87% CFC-12, 13% DME) are proposed as 'drop in' substitutes for CFC-12. The substitutes however can at best reduce ODP by 30 to 40% of the CFC-12 value and cannot altogether eliminate it.

In Western countries these mixtures are regarded as interim substitutes to help reduce their CFC consumption to be below the control limits. In view of uncertainties with HCFCs and HFCs, because of toxicity and global warming issues, it may be necessary to go in for 'drop in' transitionary substitutes.

'Drop-in' substitutes will play an important role in bringing down the cost of switch over as equipment need not be changed. They also will help for recharging of the equipment which still have life after the year 2010, thereby reducing the cost of scrapping to consumers.

Near Azeotropic Mixtures

A variety of binary and ternary near-azeotropic mixtures have been proposed in various proportions of HFC-152a, HCFC-124 and HCFC-22. The ternary blend has an ODP of 0.03 and GWP of 0.16. It is also more toxic than CFC-12.

Extensive testing of the 'Mixtures' in various proportions of the constituent elements will be necessary to select the proper refrigeration lubricant and to confirm compressor reliability and refrigerator performance and efficiency.

It will also be necessary that each constituent element of the mixtures are evaluated for flammability and for toxicity.

6.1.2 Substitute for CFC-11

HCFC-123

It has ODP of 0.02 and GWP of 0.02. Because of the close matching parameters with CFC-11, especially the boiling point, and the very low values of ODP (0.02) and GWP (0.02), HCFC-123 was till recently regarded as the ideal substitute for CFC-11 both in 'Refrigerant' and in 'Blowing agent' applications.

It is non-flammable and does not require an equipment change for foaming. However, HCFC-123 has a higher solvent action and development of special plastics will be necessary.

Short term PAFT test recently announced, however, has given adverse toxicity rating. Final PAFT test results will be known only in 1992-93.

HCFC-141b

This chemical has a ODP value of 0.09, GWP of 0.09 and is flammable and mutagenic. PAFT tests on this chemical are in progress and the results are expected only in 1992-93.

Because of flammability, substantial equipment changes will be required in the foaming area.

Because of its reactivity with plastics, a special extruded film for the liners will have to be used.

Work in the area of compatability with plastics and metallic materials and plastic/foam inter-actions are continuing.

There seems to be only limited experience available at present with foams based on HFC-141b world over.

The search for a suitable substitute for CFC-11 is not over and experts of the Western countries believe that the failure of HCFC-123 in PAFT tests may delay the phasing out of CFC-11.

Glass Wool

Glass wool, in the past, has been used as thermal insulation in refrigerators and deep freezers. This, however, required bigger dimensions of outer shell due to higher K-value. With the glass wool, Refrigerator assembly is generally manual. With the advent of the automation, many countries including India, have shifted over to foam insulation in order to achieve uniform insulation, which results in lower energy consumption.

Glass wool, however, is a zero ODP, zero GWP product.

6.2 Deep Freezers, Visi Coolers and Bottle Coolers

Substitution status for these refrigeration products will remain essentially same as that of Refrigerator.

6.3 Water Cooler

In smaller capacities, and those made by refrigerator manufacturers, the compressor used with refrigerator is also used in the water cooler. In this respect the substitute will be same as that preferred for the refrigerator.

For higher capacities HCFC-22 is used in the compressor and this will continue as it is not a banned substance at present.

6.4 Mobile Air Conditioning - Car, Bus and Train

The following substitutes are suggested :

HCFC-22, the mixtures HCFC-12/HCFC-124, HCFC-22/HCFC-142b and HFC-134a.

HCFC-22 is not well suited for mobile air conditioning because of higher pressure, greatly reduced oil solubility and considerably greater permeation.

Mixture HCFC-22/HCFC-141b, somewhat flammable, has been found to be possibly mutagenic. Mixtures tends to separate during the evaporation and condensation stages. This results in a significant loss in cooling performance in current systems when compared with CFC-12.

HFC-134a is regarded as the best possible alternative. Commercialisation of HFC-134a in car A/c is in progress in the developed countries.

6.5 Central Air Conditioning

In central air conditioning a number of reciprocating compressors are designed to operate on either CFC-12 or HCFC-22. Phasing out of CFC-12 thus poses no problem.

For larger capacities, screw compressor technology, which uses either HCFC-22 or Ammonia, is established.

The problem of substitution exists with centrifugal compressor (Chiller plant) where CFC-11 is used as the refrigerant. Such compressors are used in multistorey buildings where space is at a premium. Abroad these compressors are redesigned for use with HCFC-123. HCFC-141b is the other alternative but the material compatibility problems are yet to be solved. A trend, developing in Western countries, is to locate the central refrigeration plant based on Ammonia at a distance from the multistorey building and to convey the cold water to the building through pipes.

6.6 Cold Store

Phasing out of CFC-12 poses no problem as 95% of the existing cold stores are based on Ammonia as a refrigerant.

6.7 Ice Candy Machines

Compressor technologies which can use either HCFC-22 or CFC-12 as refrigerant are well established. Phasing out of CFC-12 in this application is, therefore, no problem.

6.8 Room Air Conditioning

For room air conditioners, one of the manufacturers is using CFC-12 for capacities of 1.0 TR or below and HCFC-22 for higher capacities. It should be possible to use the bigger compressor based on HCFC-22 for smaller tonnage also and this can be studied further.

For higher capacities and also for packaged air conditioners, HCFC-22 is already in use.

6.9 Summary

It can be said that the phase out of CFCs in Refrigeration & Air Conditioning Sector is important only in domestic refrigerators, freezers, bottle coolers and for mobile air conditioning - Car, Bus & Train and for Centrifugal compressors used in Centrifugal Chillers. A clear picture on the substitutes & technologies is expected to emerge in the next one or two years. This need not cause concern in Indian context as we have a grace period of 10 years available over the developed countries for phase out.

For other products in this sector alternative substitute. like HCFC-22 are available in the country.

A select list of manufacturers of CFC substitutes abroad is given in Appendix V.

7. PHASE OUT STRATEGY

In Indian context, there is not much difference between 'consumption' and 'production' of CFCs, as there are currently no destruction plants for CFCs based on approved technologies in India and also the exports and imports are insignificant. Of the Group I substances, a small quantity of CFC-113 is imported.

As the controls apply to the Group I substances of Appendix-III as a 'whole', any phase out strategy must strictly take into account the consumption of these substances in sectors other than Refrigeration and Air Conditioning also.

The strategy suggested here is based on the consumption figures of the Refrigeration and Air Conditioning sector only. It is expected that the task force will take into account similar phase-out strategies suggested by other Sub-groups and evolve an integrated National Strategy for phase-out for all sectors.

Table 7.1 gives a summary of unrestrained consumption figures of CFC-12, 11 and HCFC-22 for 1990 to 2010 as estimated in Section 4 for the Refrigeration and Air Conditioning industry. Figures for HCFC-22 reflect the growth in its demand when no constraints are applied on CFC-12.

In 1996 the total demand will be 4323 ODP tonnes and this figure will be approximately the 100% base figure for Montreal Protocol limits (the correct figure will be the average of production during three calender years 1995, 1996 and 1997). In 2005 and 2007 the consumption will be limited to 2162 and 648 ODP tonnes respectively. In 2010 this figure has to be brought down to zero.

It must be emphasized that formulating the strategy to phase out CFCs which are closely linked to developing economy of India difficult. Further, such strategy should in no way affect the growth of industry and socio-economic patterns. Stated below are certain directions in which such strategies should be oriented.

In order to comply with the Protocol schedules, the possible mechanisms available for control as under :

- Redesign of the appliances and components so that the per unit consumption is reduced.

- Reduction of emissions of CFCs through better manufacturing and service practices.

- Reduction through recovery and recycling.

- Reduction through substitution of CFC Technologies by proven Non-CFC Technologies available and in use.

- Use of foam materials which require less CFC.

- Replacing CFC by a CFC substitute, but essentially usin the same manufacturing technology for the product.

- Replacing CFC using product by another product which works on a different principle.

- Use of alternate thermal insulation which require no CFC

Each one of the above mechanisms require considerable amount of Research, Development, Training, Engineering and establishing manufacturing processes.

The status of CFC substitutes has already been discussed in Section 6.

7.1 Considerations for formulation of CFC phase out strategy

Apart from the mechanisms available, there are several considerations which can be taken advantage of, for formulating a viable phase out strategy to comply with the protocol limits.

7.1.1 Prioritisation for phase out between different products within Refrigeration & Air Conditioning sector

In Water Coolers and Room Air Conditioners compressors based on HCFC-22 are already in use in the country. Similarly for Central Plants and Cold Stores, technologies based on HCFC-22 and Ammonia are well established. In fact a number of these systems are designed to operate on CFC-12 or HCFC-22 and HCFC-22 or Ammonia. It should not be difficult to phase out CFC-12 from these applications at an early date.

It is also possible to convert the refrigeration system of Ice Candy Machine to be based on HCFC-22. As the majority of these products are made in unorganised sector, the compressor manufacturers could be persuaded to offer HCFC-22 refrigeration systems.

7.1.2 Recharging Consideration

Table 7.2 indicates that the requirement of CFC in 2010 for recharging in an unconstrained growth situation (8291 ODP tonnes) exceeds the Montreal Protocol base limit of 1996 (4323 ODP tonnes).

The protocol requires that the consumption, which includes both initial charging, blowing and recharging should be brought to zero by that time. While initial charging and blowing agent requirements can be met by CFC substitutes, the recharging requirement can be made zero only if all CFC based appliances exhaust their product life by 2010.

This requires that each product now consuming CFC-12 must be phased out at such a time that its product life is over by 2010. For instance CFC-12 refrigerators which have product life of 15 years will have to be phased out in 1996. If their (refrigerators) phase out occurs in 1999, there will be over 121 lakhs refrigerators left in the field requiring CFC-12 recharge for 3 more years after 2010. Similarly the phase out of Deep Freezers, Bottle Coolers, Water Coolers must start in 2000 and so on. 'Drop-in' substitutes (like ternary blend of HCFC-22/HFC-152a/HCFC-124) can, however, be used for recharging these equipment to overcome this problem.

7.1.3 Quantity of Consumption Consideration

The consumption of CFCs in 1996 by Central plant and Ice Candy machines is of the same order as that of Refrigerator, Deep Freezers and Bottle Coolers put together. This is because the per unit consumption of CFCs in these products is very high.

An effective strategy will be one in which products, requiring larger consumption and for which alternative technologies are available, are phased out earlier so as to give more head room for more difficult products.

7.1.4 Level of Technology of Products

In some of the products like Cold Stores, Central Plants and Ice Candy machines it is not difficult to change over to substitute technologies which are available established and in use. This can be done at an early date during phase down.

7.2 Phase-Out Strategies for Refrigeration and Air Conditioning Sector

Taking into account all the above considerations two phase-out scenarios as under are suggested :

Date	Early Substitution - Scenario I	Late Substitution - Scenario II
1.1.1999	50% CFC-12 phase-out in compressors of Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12	—
1.1.2000	- 100% CFC-12 phase-out in Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12 - 100% conversion of CFC-12 compressors of Central Plant, Cold Store, Ice Candy Machines and Room A/C to HCFC-22 - 50% CFC-11 reduction in foam	- 50% CFC-12 phase-out in Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Centrifugal Chillers and Mobile A/C based on CFC-12. - 100% conversion of CFC-12 compressors of Central Plant, Cold Store, Ice Candy Machines and Room A/C to HCFC-22. - 50% CFC-11 reduction in foam.
1.1.2005	- 100% change over of CFC-11 Centrifugal Chiller by CFC-11 substitute - 100% CFC-11 reduction by CFC-11 substitute in foam of Refrigerators, Deep Freezers and Bottle Coolers.	- 100% change over of CFC-12 by CFC-12 substitute in Refrigerators, Deep Freezers, Bottle Coolers, Water Coolers, Mobile A/C and Centrifugal Chillers based on CFC-12. - 100% change over of CFC-11 by CFC-11 substitute in foam and Centrifugal Compressors.
1.1.2010	- Residual recharging requirements to be met by recovery/recycling, or drop-in substitutes or retrofitting the compressors.	- Residual recharging requirements to be met by recovery/recycling, or drop-in substitutes or retrofitting the compressors.

Fig.7.1 shows the reduction of consumption of CFCs in this sector in terms of the two scenarios against the backdrop of Montreal Protocol schedule applied to this sector only.

The Early Substitution - Scenario I is based on the assumption that CFC-12 substitutes and technology for manufacture of substitutes/appliances/products are available by 1996/1997 and similarly CFC-11 substitutes and technology for manufacture of substitutes/appliances/products are available by 2000/2001. This scenario has the merit that the number of appliances/products requiring recharging or scrapping or are needed to be destroyed by approved destroying technologies in 2010 are less.

Late Substitution - Scenario II takes into account of any possible delays in the availability of CFC-free substitutes or technologies beyond 1996/1997. In this case, however, the consumption could not be contained to the 100% freeze limit by 2010. The situation can, however, change in the National Phase-out Strategy where CFC consumption in other sectors will also be considered and where it may be possible to adopt CFC-free technologies earlier.

Both scenarios bring out that emission control through better manufacturing and service practices, the recovery and recycling technologies and switch over to HCFC-22 in the suggested products be accorded the highest priority.

Table 7.3 A&B give the consumption of CFC-11 & 12 substances as per the two scenarios.

Table 7.4 shows the consumption of HCFC-22 as affected by the above action plan. It can be seen that the present capacity of HCFC-22 of around 16,000 MT is adequate to meet the requirements till 2007. By that time the status of HCFC-22 in an International scenario will be known and appropriate decisions can be taken whether to increase the capacity or substitute it with a new technology.

Table 7.5 A&B give the growth of demand of the substitutes for CFC-12 and CFC-11.

If 3000 tonnes is assumed as an economical quantity for manufacture of CFC substitute, this demand will be reached around the year 2007 for the CFC-12 substitute and by 2005 for CFC-11 substitute. The plants for the same can be planned accordingly to meet the above requirements.

TABLE 7.1

SUMMARY OF CONSUMPTION OF CFC-11,12 & HCFC-22

(Metric Tonnes)

USE	1990			1996			2005			2007			2010		
	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22	CFC-11	CFC-12	HCFC-22
Refrigerator	342	268	—	1290.0	637	—	3636	1969	—	4396	2432	—	5854	3301	—
Deep Freezer/ Ice Cream Cabinet	—	13	—	5	26	—	10	55	—	12	62	—	14	75	
Bottle Cooler/ Visi Cooler	—	4	—	9	10	—	18	22	—	21	26	—	26	31	—
Water Cooler	—	13	13	—	25	25	—	50	50	—	57	57	—	67	67
Car AC	—	169	—	—	473	—	—	1174	—	—	1400	—	—	1831	—
Bus & Van AC	—	20	—	—	44	—	—	126	—	—	163	—	—	238	—
Train AC	—	29	—	—	48	—	—	97	—	—	110	—	—	127	
Central AC Plant	155	242	1459	329	495	2743	989	1448	7766	1326	1841	10106	1955	2634	13647
Cold Store	—	55	—	—	119	—	—	352	—	—	444	—	—	630	—
Ice Candy M/c	—	552	—	—	647	—	—	851	—	—	886	—	—	941	—
Room AC	—	105	350	—	166	560	—	249	833	—	266	892	—	297	991
Packaged AC	—	—	67	—	—	136	—	—	374	—	—	472	—	—	662
Others (Navy & Shipping)	—	160	243	—	—	356	—	—	486	—	—	516	—	—	564

TABLE 7.2

TOTAL CONSUMPTION FIGURES OF CFC-11, 12 & HCFC-22

(Metric Tonnes)

	1990	1996	2005	2007	2010
CFC-11					
- Initial Charge & Foaming	384	1338	3928	4771	6404
- Recharge	113	245	725	984	1445
Total	497	1633	4653	5755	7849
CFC-12					
- Initial Charge	579	801	2047	2483	3326
- Recharge	1051	1889	4346	5204	6846
Total	1630	2690	6393	7687	10172
HCFC-22	2132	3820	9509	12043	15931

te : Does not include the consumption in Aerosols and foam excluding refrigerators.

TABLE 7.3A

CONSUMPTION OF CFC-11 & CFC-12 TILL 2010 (EARLY SUBSTITUTION - SCENARIO I)

(Metric Tonnes)

	1990	1996	1998	1999	2000	2005	2007	2010
CFC-11	497	1633	2152	2467	1685	725	725	725
CFC-12	1630	2690	3307	1780	1441	1116	913	455
TOTAL	2127	4323	5459	4247	3126	1841	1638	1180

TABLE 7.3B

CONSUMPTION OF CFC-11 & CFC-12 TILL 2010
(LATE SUBSTITUTION - SCENARIO II)

(Metric Tonnes)

	1990	1996	1998	1999	2000	2005	2007	2010
CFC-11	497	1633	2152	2467	1685	725	725	725
CFC-12	1630	2690	3307	3682	2046	1775	1572	1022
TOTAL	2127	4323	5459	6149	3751	2490	2297	1747

TABLE 7.4

CONSUMPTION OF HCFC-22 AS AFFECTED BY PHASE OUT SCENARIOS*

(Metric Tonnes)

	1990	1996	2005	2007	2010
HCFC-22	2132	3820	11947	14912	19625

* Same for both Scenarios.

TABLE 7.5A

ESTIMATED DEMAND OF CFC-12 AND CFC-11 SUBSTITUTES
(EARLY SUBSTITUTION - SCENARIO I)

(Metric Tonnes)

Year Substitute	1999	2000	2005	2007	2010
CFC-12 Substitute	478	1151	2637	3664	5590
CFC-11 Substitute	--	--	3928	4995	7098

TABLE 7.5B

ESTIMATED DEMAND OF CFC-12 AND CFC-11 SUBSTITUTES
(LATE SUBSTITUTION - SCENARIO II)

(Metric Tonnes)

Year Substitute	1999	2000	2005	2007	2010
CFC-12 Substitute	--	545	2308	3183	5037
CFC-11 Substitute	--	--	3928	4995	7098

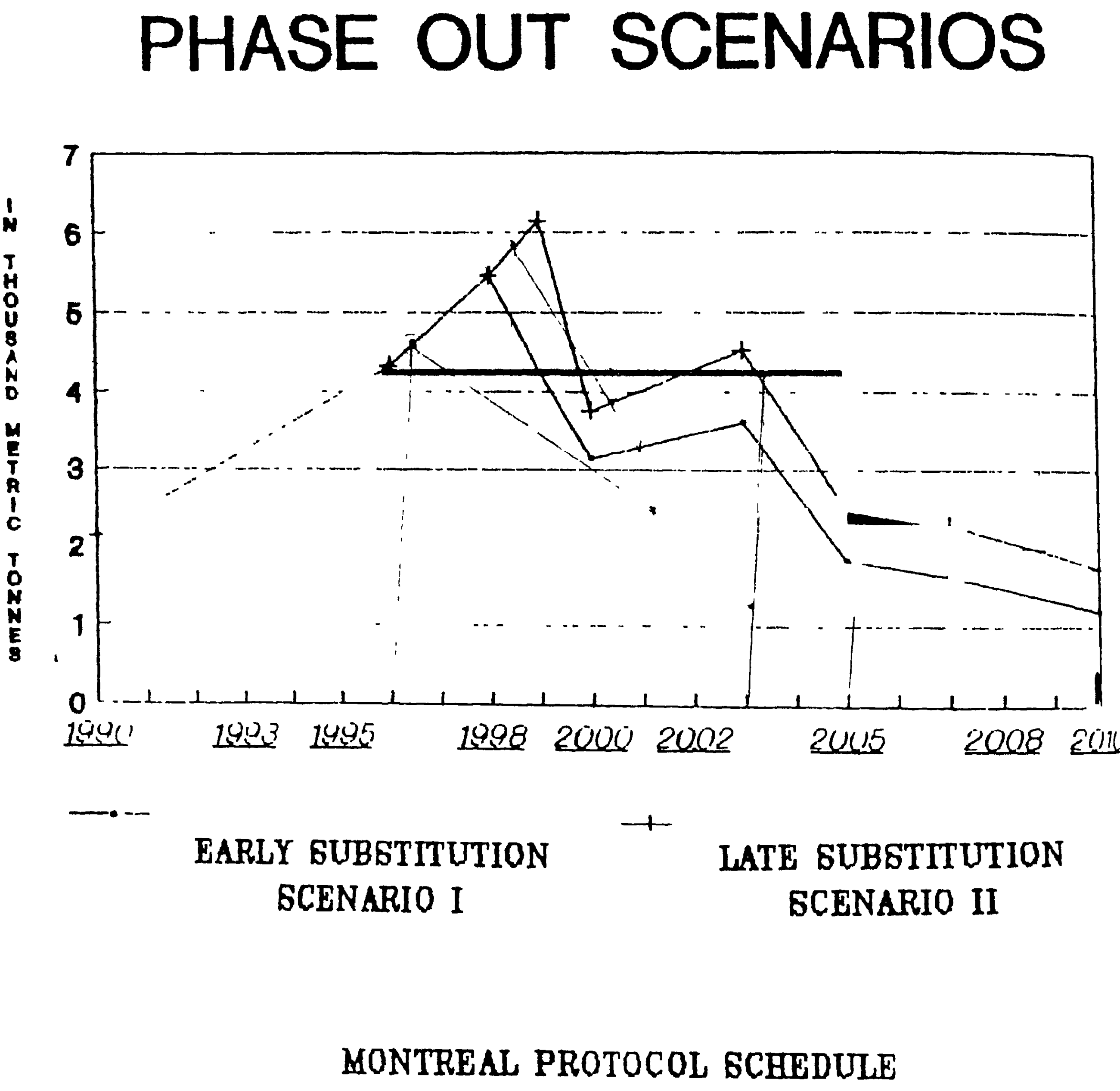
PHASE OUT SCENARIOS
IN THOUSAND METRIC TONNES
0
1
2
3
4
5
6
7
1990
1993
1995
1998
2000
2002
2005
2008
EARLY SUBSTITUTION SCENARIO I
LATE SUBSTITUTION SCENARIO II
MONTREAL PROTOCOL SCHEDULE

FIG-2.1

8. EMISSION REDUCTION, RECOVERY AND RECYCLING

It is increasingly being realised that, as emissions of CFCs are the ones that cause Ozone depletion, an emission that takes place now will have the damaging effects for decades to come. Steps for controlling these emissions can be taken without waiting for the availability of CFC substitutes.

Also as a substantial population of Refrigeration equipment are based on CFCs, emissions from these can be expected to continue during the life time of the product which may extend beyond the 100% phase out time limit (2010) and at that time no CFC is likely to be available.

Further, the amendment of the Montreal Protocol bringing down the production and consumption limits from 50% to 0% by 2010 AD has also lent urgency to the adoption of measures to reduce emission and to recover and recycle the CFCs for future use.

Fortunately measures for emission reduction, recovery and recycling of CFCs can be applied in all countries developed or otherwise, but these may differ from one country to other depending on the climate, usage, work ethics, cost, level of skills and logistics available.

A detailed country based analysis is necessary to decide the measures to be adopted for each CFC based product.

8.1 Emission Control

There are two types of situations where CFC emissions take place. In one type emission is direct and due to its very application i.e. aerosol. In other emission is not intended but takes place during manufacture and service of appliances/equipment i.e. refrigerant in vapour-compression cycle and foams.

8.2 Emission Reduction

In advanced countries, Industry/Research Associations like IIR and ASHRAE have taken initiatives to critically evaluate the emission reductions possible and suggested the following solutions.

One of the solutions suggested is that "things done today are done better" and, to ensure the same, "Codes of good practice" are proposed. Two of them worth mention are - EUR 9509 EN and ASHRAE Guideline 3-1990.

Similar codes of practice need to be evolved after a study of the present manufacturing/operating/service practices in India. ASHRAE and AIACRA could take the initiative.

Alternatively a Consultancy firm, active in the rea of Refrigeration and Air Conditioning, can be assigned the job.

The other feasible solutions are :

a. To minimise the requirements of refrigerant through suitable redesign.

b. Recovery and recycling.

8.3 Recovery and Recycling

The recharging demand of the refrigerants CFC-11 and 12 in refrigerating equipment arising out of leakages, venting and scrapping form about 55% of the CFC consumption in 1990.

In an unconstrained CFC consumption scenario this percentage is 46% by 2010 and is almost 191% of the base figure in 1996 for Montreal Protocol implementation. The Protocol requires this consumption should be brought to zero by 2010.

Recovery and recycling of Refrigerants thus assume importance in the practical implementation of any phase out strategy.

Where individual equipment use large volumes of CFC-12 or 11 as in Central Plants, Cold Stores, Package Air Conditioners, Bus and Train Air Conditioning systems, recovery should be relatively easy although some design changes may be required to facilitate easy recovery. In all the above equipment a maintenance crew will be available at the plant or in case of mobile system at the Maintenance/Servicing bay.

As a general rule in Developed countries big refrigerant users will recycle their used material if the cost of recycling is not more than 50% of the cost of the new refrigerant. If this limit is exceeded, the contaminated refrigerant will be usually vented rather than spending time and effort to recapture and reprocess. Recycled refrigerant is generally used in any system which requires a minimum of 45 kg. (See 'Operating Experiences of a Refrigerant Recovery Services Company', by O' Meava, D.R., ASHRAE Transactions, , Vol.94, Part 2, 1988)

Recovery of CFCs from smaller equipment like Refrigerators, Room Air Conditioners, Water Coolers and Car Air Conditioners is more difficult because of the large numbers, wide dispersal and the cost of collection and transport in economical quantities to the recycling stations. It is necessary to organise the collection, transport, purification and recycle of such refrigerants from such widely dispersed appliances, if the country has to meet its recharging requirements beyond 2010.

A recovery cum recharging station may not be portable but can be made mobile. This will be a limiting factor for its use.

8.4 Recovery and Recycling Equipment

Abroad these equipment are nowadays available for capacities upwards of 5 kg gas in the following options

- Recovery only
- Recycling only
- Recovery and Recycling

Some of these models have multi refrigerant options.

The present price of a recovery or a recycling equipment each cost approximately 900 to 1000 $ for a 5 kg capacity.

8.5 Recovery and Disposal of CFCs from Scrapped Appliances

In India refrigerators and even air conditioners are regarded as lifetime purchases. During the lifetime, in some cases, the possession of the equipment may change from first owner to second owner. Finally when the owner is unable to meet the cost of repair the equipment lies in disuse in his house or outside. In India there are no specific regulations for destructing the scrapped appliances.

The service mechanics can be encouraged to purchase these appliances at a rate more than the scrap rate of the materials and recover the refrigerant from from it using a recovery equipment at his service station. A subsidy may be given to him for each such machine collected as logistics and cost of recovery involve substantial costs to him.

8.5.1 Disposal of CFC-11 from Insulating Foams

In a refrigerator with insulating foam and a metal shell, the leakage of CFC-11 is extremely low and is about 1% for each year of life.

This suggests disposal of the foam in as intact a state as possible since only destroyed cells lose their gas at once, while diffusion from neighbouring cells takes a relatively long time. The following possibilities are conceivable : recycling by mechanical grinding with thermal desorption and recondensation of the escaping gaseous CFC-11; disposal by qualified incineration, i.e. thermal destruction above approximately 850°C with subsequent flue gas scrubbing. Only disposal by incineration is technically and economically reasonable in present scenario.

As CFC-11 used for polyurethane foams is needed the insulation of refrigerators and freezer, an appropriate disposal method will have to be developed. A major requirement is the establishment of a transport system to ensure the transfer of refuse to adequately sized incineration plants with specified size limits up to which polyurethane insulations can be precrushed to facilitate transport.

The cost of disposal of the refrigerant CFC-12 and of waste oil has to be worked out in the Indian context.

8.6 Strategy in Indian Context

The following strategies for control of emissions, recovery/recycling of CFCs are suggested.

1. Study and analysis of various measures for reduction and controlling the CFC emissions along with recycling and recovery. This study should consider practices followed abroad and special situation existing in India.

2. A code of practice to control emissions in manufacture operations and servicing of refrigeration and air conditioning equipment is to be immediately prepared.

   This may be assigned as a consultancy project involving ISHRAE and industry immediately.

3. Industries in the Pollution Control business may be encouraged to develop the recovery and recycling equipment.

4. Exemption of excise duty and other fiscal benefits may be provided for purchase of the equipment so that mechanics, service stations, manufacturing companies and users can be encouraged to buy and utilise the equipment.

5. In some countries, it is mandatory for service stations to own a recovery equipment. A similar regulation can be considered.

6. A further rebate in price can be considered on the deposit of recovered gas at authorised recycling station.

   Initially, in all major cities (A, B and C) Authorised recycling stations may have to be established at the Regional Offices of the CFC manufacturers.

7. It will be necessary to make provision in the design of the equipment for mechanisms for recovery of refrigerants from refrigerators/air conditioners. There is a need for standardisation of the valves and quick couplers and the tubes for this purpose. The Bureau of Standards in collaboration with the Industry Association like ISHRAE, AIARCON and IIT's or other research institutes can prepare these standards.

8. It is necessary to commission a Consultancy Organisation to study all aspects of scrapping of refrigerators, air conditioners etc. and cost of either recycling or incineration.

9. A scheme for retraining and certification of the mechanics for implementing the new code of practices is necessary.

9. RESEARCH AND DEVELOPMENT STRATEGIES

Considering the status of CFC-substitutes, R&D strategies are proposed with the following objectives :

Objectives of R&D

i) Development of Data base
ii) Evaluation and assessment of the substitutes to provide technical support to the Indian industry for adoption of appropriate substitutes under Indian conditions. Evaluation should also take into account Indian economic situation including the export requirements.
iii) Development of methods for recycling, recovery and reclaim.
iv) Development of CFC-free technologies for refrigeration and air conditioning applications.

9.1 Evaluation of CFC Substitutes Chemicals such as HFC-134a, HFC-152a, HCFC-123, HFC-141b etc.

- ✓ Screening of possible alternatives including drop-in-substitutes
- ✓ Evaluation of thermodynamic and transport property data
- Flammability data evaluation
- Analysis of toxicity and environmental acceptability data
- ✓ Material compatibility tests - short and long term effects of these chemicals on materials of construction such as steel, aluminium, copper, enamels, paints, epoxy coatings etc.
- Formulation of handling procedures for substitute chemicals

9.2 Evaluation of Mixtures of Refrigerants

- Identification of promising azeotropic, near azeotropic and non-azeotropic mixtures as refrigerants.
- Evaluation of thermodynamic and transport property data with a view to obtain a retrofit substitute (drop-in) for CFC-12, CFC-11 and others.

- Flammability data evaluation
- Materials compatibility tests
- Analysis of toxicity, environmental acceptability data.
- Formulation of handling procedures for substitute chemicals.

9.3 Lubricants for Use with Substitutes (HFC-134a, HFC-152a etc.) and Mixtures of Refrigerants

- Evaluation of promising lubricating oils
- Studies on miscibility of lubricating oils with substitute chemicals.
- Evaluation of thermodynamic and transport property data of compatible lubricating oil and refrigerant mixture.
- Long term tests on prototype compressor with substitute chemicals and compatible lubricating oil.
- Design modification of refrigeration system based on miscibility and immiscibility characteristics of oils with refrigerants.

9.4 Refrigerant

- Bench scale studies for process development of CFC-substitutes.

9.5 Polyols

- Characterization of imported polyols which require 50% CFC-11.
- Characterization of imported polyols for use with HFC-123, HFC-141b.
- Foam characteristics of the above as per ASTM standards.
- Interaction of foam with plastics, steels, aluminium, copper, epoxies and paints.

9.6 Performance Studies

- Computer simulation of refrigeration cycles and system components using substitute chemicals.
- Performance evaluation of existing compressors with substitute chemicals (HFC-134a, HFC-152a etc.) and compatible lubricants.
- Life tests on existing small capacity refrigeration units (refrigerators, water coolers, car air-conditioners etc.) with compatible lubricating oils and CFC substitute chemicals.
- Studies on winding temperatures compressor noise and other characteristics of hermatically sealed compressors with compatible oils and substitute chemicals.
- Performance of refrigerators with CFC-12 compressor but with a) 50% CFC11in foam, b) HCFC-123 c) HFC-141b.
- Energy efficiency studies with existing refrigerator and other equipment under various operating conditions.
- Energy efficiency studies with the new compressors but with CFC-11 foam under the same operating conditions.
- Energy efficiency studies with CFC free new compressor and refrigerator.
- Development of energy efficient and high CFC-12 Index refrigerator with CFC free new compressor and refrigerator.

9.7 Recovery, Recycling & Reclaiming of CFCs

- Operation of recovery equipment with refrigerators, water coolers, deep freezers and visi bottle coolers.
- Study of recovery equipment.
- Study of recovery equipment for centrifugal plants.
- Characterization of recovered gas and comparison with originally manufactured chemicals.

- Purification studies of recovered chemicals.
- Formulation of standards for use of recycled chemicals.
- Preparation of literature for recovery.
- Education and training of mechanics for recovery, recycling and service practices.

9.8 Studies on Environmental Friendly Technologies Related to Refrigeration & Air Conditioning Sector

- Screening of environment-friendly substances for vapour comparison, vapour absorption & other systems.
- Evaluation of thermodynamic and transport properties of new working fluids.
- Development of environment-friendly insulating materials.
- Development of equipments using such working fluids.

9.9 National Centre for Refrigeration and Air Conditioning

It is recommended that a 'National Centre for Refrigeration & Air Conditioning' be established to study these various problems in collaboration with National laboratories, IITs and industries. An initial investment of Rs.10 crores is estimated.

The Centre should also have one division which could be assigned the responsibility for promoting recovery and recycling technologies, for education of industry personnel and customers on Ozone friendly substances and Technologies.

The National Centre can also provide assistance to the unorganised sector on better methods of processing and manufacturing and also to cope with the design changes brought out by the substitution of CFCs by Ozone friendly chemicals.

10. INCREMENTAL COSTS FOR PHASING OUT

Costs for phasing out CFCs or more broadly ODSs will be incurred by all the affected segments - ODS producers, producers of associated chemicals like Polyols, lubricants etc., Equipment/Appliance manufacturers, compressor manufacturers, Users of Equipment/Appliance. The ripple effect will also be felt by Electric, Water, Air supply industries if the consumption of these are altered by the CFC substitution.

A precise calculation of the costs at this stage is difficult and only a broad indication for Refrigeration and Air Conditioning sector can be given for the following reasons.

- The ODS producers produce chemicals other than CFC-11 and 12 and supply these and the other chemicals to other sectors of industry. Scales of economics for manufacture of substitutes play a big part.

- The national CFC phase out strategy for all sectors is to be evolved and agreed both in terms of sequence and timing of products/systems for substitution.

  The strategy proposed in Section 7 - Early Substitution - Scenario I and Late Substitution - Scenario II is a proposal from R&AC sub-group only.

  The costs are worked out on '1991 rupee basis' for the two scenarios and expressed in dollars. The inflationary effects and interest costs can be taken into account and the year by year phase out cost can be calculated, once the national CFC phase out strategy is worked out by the Task Force.

10.1 Identification of Segments

The identified costs for various segments of relevance to R&AC industry are as under :-

CFC Producers	- Loss on account of restriction on CFC production much below the limits of installed capacities. - Modification of plants to change the product mix in favour of HCFC-22. - Loss of production during shut-down for modification.

	- Building a new capacity to manufacture substitutes for CFC-11 and 12 and the economic viability of the scales of manufacture (3000T per annum). - Development costs for substitutes/ Technology Transfer fees.
Refrigeration and Air conditioning equipment manufacturers	- Development of new designs, toolings, fixtures, vendor items, new plastics. - Loss of production on account of stoppage of the manufacturing line to introduce new designs, tools, fixtures etc. - Modification/replacement of Plant and Machinery to suit the toxicity and flammability and other parameters of substitute chemicals. - Development costs for trials, tests, designs with CFC substitutes. - Extra operational costs because of new processes involved.
R&D	- Establishment of National Centre. - Funding of R&D projects. - Equipment & facilities. - Bench-scale tests.
Consumers	- Increased price because of new designs and costly CFC substitutes and compatible materials. - Scrapping of CFC based appliances. - Possibility of increased electricity costs.

The costs will have to be worked out on a economically viable unit basis - for Refrigerators 5 lacs is considered as the unit - for the manufacture of the CFC substitutes, Refrigerators, Compressors for other applications, equipment and systems.

10.2 Costs of Phasing Out for CFC Producers

Raw material/Feed stock Manufacturers (solvent + HF)	75 x 2	=	150.00 Crores
CFC Substitutes (for CFC-11, CFC-12) manufacturers for an economic unit of 3000T	100 x 2	=	200.00 Crores
Technology Transfer & development costs	25 x 2	=	50.00 Crores
			400.00 Crores

It is assumed that the manpower retraining costs are also included under the developmental costs.

10.3 Costs for Phasing Out for Refrigeration and Air Conditioning Equipment Manufacturers

10.3.1 Refrigerators

The costs are worked out for substitution of CFC-12 by HFC-134a and CFC-11 by HCFC-123/HFC-141b. Price of HFC-134a and HCFC-123 are assumed to stabilise at 5 and 2.5 times the price of CFC-12 and 11 respectively. A unit of 5 lacs is considered.

Substantial modification/purchase of machinery are visualised. It is assumed that the compressor and refrigerator models will be obtained through Technology Transfer.

Details of estimated costs are as under :-

Cost of conversion of one model of refrigerator/ deep freezer (including compressor-design, technical fee of design, indigenisation, tooling, fixtures & gauges, R&D and tooling trials, modifications in foaming stations etc.) for 5 lacs capacity	Rs. 24 crores
Additional cost assumed at 50% of the above for variety in compressor models (1/6, 1/4, 1/3, 1/2 etc.), Refrigerator models (90L, 165L, 310L) and deep freezer models (85L, 275L, 425L etc.)	Rs. 12 crores
TOTAL	Rs. 36 crores

With a level of manufacture of refrigerators/deep freezers etc. in 1998 of 40 lacs approximately, the total cost of conversion will be Rs.288 crores.

10.3.2 Compressors

This applies only to open & semi-open type of compressors, used in large deep freezers, Bus & Van Air Conditioning, Train Air Conditioning, etc. where CFC-12 is at present used as the refrigerant.

1.5 lacs capacity is regarded as an economical unit. Cost of conversion is estimated at Rs.12 crores.

10.3.3 Car Air Conditioning

Like Refrigerators/deep freezers etc., this product is sure to be affected by the phasing out of CFC-12. It is assumed that the CFC substitute refrigerant used in this application will be same as that for Refrigerators and deep freezers.

For a forecast of demand of 2 lacs per year required in 1998, the conversion cost is estimated at Rs.50 crores.

10.3.4 Centrifugal Chillers

There are four manufacturers of Centrifugal Chillers using CFC-11 and 12. The change over will require Rs.20 crores approx.

10.3.5 Summary

Table 10.1 gives the summary of cost of conversion on 1991 'Rupee' basis for Refrigeration and Air Conditioning products.

TABLE 10.1

Refrigerator, Deep Freezer, Bottle Coolers, Small Water Cooler, Visi Cooler	Rs. 288 crores
Car Air Conditioning	Rs. 50 crores
Compressors required for applications other than car air conditioning	Rs. 12 crores
Centrifugal Chillers	Rs. 20 crores
TOTAL	Rs. 370 crores

Cost estimates made above are only tentative & these will get clarified as more and more information is available about the substitute and the impact on design.

10.4 R&D Costs

The break up of costs for the R&D programmes indicated in Section 9 are as under :

Establishment of the National Centre for Refrigeration and Air Conditioning	10 crores
Equipment and facilities cost	16 crores
Cost of working out R&D programmes at 3 centres on average	18 crores
Bench scale tests for substitutes and new polyols	6 crores
	50 crores

10.5 Cost to the Consumer

The average cost of a working appliance near about the end of its life is approx. 20% of the cost of the new appliance/equipment. The user will not be able to realise this money if he owns a CFC based appliance/equipment and he wants to dispose it off after 2010. A compensation to this extent will have to be provided to him either as a concession in the purchase of a new non-CFC appliance or as a rebate provided for in excise duty for such cases.

The costs of scrapping of refrigeration appliances/equipment is calculated for the Early Substitution - Scenario I and Late Substitution - Scenario II respectively based on the population of these appliances/equipment with left over life beyond 2010. The details are given in Table 10.2.

The incremental cost to customer due to change of designs, CFC substitutes, and operational cost including energy are not taken into account.

This cost will get reduced if 'drop-in' substitutes (like ternary blends - HCFC-22/HFC-152a/HFC-124) are used for recharging purposes.

10.6 Costs of Destroying CFCs

In both phase out scenarios, CFC-11 in foam of the refrigerators is phased out by 2005. Although the CFC-11 consumed is taken into account in terms of the Protocol and also the phase out scenarios an investment will be necessary if the foams have to be disposed off in such a way as not to give Ozone depleting emissions into the atmosphere.

In 2005 the total population foamed refrigerators in India is estimated at 557 lacs (628 lacs - 71 lacs of glasswool). The cost of incineration of the same is estimated at approximately Rs.1000/- per refrigerator based on the German figures. The total cost of destroying foamed refrigerators will then work out to be Rs.5570 crores.

These costs are however not taken into account in the summary of the costs given in Section 10.10. The magnitude of the figure should however be kept in mind in any future discussions on Montreal Protocol which may call for implementing destroying technologies also.

TABLE 10.2

COSTS TO THE CONSUMER

S.No.	Product	1991 Price (Rs.)	Per Unit Scrap Cost for full product/ relevant components assumed at 20%	Early Substitution Scenario I		Late Substitution Scenario II	
				Population	Scrap Cost Rs.in Crores	Population	Scrap Cost Rs. in Crores
1.	Refrigerators	7500	1500	121 lacs	1815	275 lacs	4125
2.	Deep Freezer	18000	3600	—	—	65,000	23
3.	Bottle Cooler	18000	3600	--	—	44,000	16
4.	Water Cooler	6000	1200	—	—	60,000	7
5.	Car A/c	12000	2400	—	—	5,12,000	123
6.	Bus & Van A/c	75000	15000	1,180	2	3,990	6
7.	Train A/c	200000	40000	1,925	8	2,325	9
8.	Centrifugal Chillers of 400 TR Capacity (CFC-12 type)	6000000	1200000	600	72	800	96
9.	- do - (CFC-11 type)	6000000	1200000	3,020	362	3,020	362
	TOTAL				2259		4767

10.7 Summary of Incremental Costs for Phase Out of CFCs in Refrigeration & Air Conditioning Sector

The summary of the costs is given for the Early Substitution - Scenario I and Late Substitution - Scenario II as under : in 1991 rupees and also in dollars.

	Early Substitution Scenario I	Late Substitution Scenario II
Costs to CFC Producers	400 crores	400 crores
Costs to R&AC equipment Manufacturers	370 crores	370 crores
R&D Costs	50 crores	50 crores
Costs to customers for scrapping	2259 crores[*]	4767 crores[*]
Total in Rupees (1991)	3079 crores[**]	5587 crores[**]
Total in Million US$ (1 US$ = Rs.25.50)	1207	2190

[*] It must be noted that 'costs to consumer for scrapping' will get reduced if 'drop-in' substitute (like ternary blends, HCFC-22/HFC-152a/HCFC-124) are used for recharging the equipment which have useful life even after 2010.

[**] This however does not include the cost of destroying the foams of refrigerators etc. reflected in Section 10.9.

11. MEASURES TO ACHIEVE PHASE OUT

Once India becomes a signatory to Montreal Protocol in 1992, the limits on consumption of ODS substances come into force. The Govt. will have to ensure that these limits are adhered to, without in any way prejudicing the progress/growth of the industries involved, or discouraging the demand from the consumer.

A combination of 'Market based measures' with 'command and control' measures will be required as a part of the programme to phase out the ODS substances. The list of measures suggested are :

- To encourage the growth of demand of R&AC appliances/products through excise duty and sales tax relief so that a high figure of CFC consumption can be built by 1997 for the 'base'.
- To decide quotas on production/consumption at the producer level in 1998.
- To provide financial incentives to close production capacity of CFCs and establish CFC substitute capacities or to convert the existing capacity to the production of substitute substances.
- To provide financial incentives to close production capacity for products containing CFC and establish capacity for products containing CFC substitute or to convert the existing capacity to the production of products containing substitute substances.
- Assistance with technology transfer for compressors, based on Ozone friendly substitutes and for new foaming systems through customs duty reliefs.
- Compensation to the ultimate consumer against price increase through reduction of excise duty.
- Graded system of taxation on products containing CFCs beyond 2000 which increase over a time upto 2010.
- Encouragement to R&D aimed at retro-fitting of new compressors, recycling and recovery schemes.
- Loans/grants at nominal interest for modernization of plants to cope up with the CFC substitutes.
- Discourage import of technology based on CFCs after 1996.

- Discourage upto 1996 commercial import of CFC-substitute and related technologies till they are well evaluated under Indian conditions as indicated in R&D strategies.

- Encourage commercial import of CFC-substitute and related technologies as have been well evaluated under Indian conditions after 1996.

To ensure that producers, users and consumers become convinced of the Government's commitment, the following actions of the Govt. are necessary :

- The measures taken are well publicized to all affected groups.

- The reasons for each measure and its intended effect are explicitly stated.

- Intention to implement particular measures are announced as early as possible.

- The time table for applying measures is announced as early as possible.

- Measures which have a direct impact on the price to the customer are applied gradually.

It will be necessary for the government to create an agency/Board to monitor the implementation of the phase out strategy, the effect of measures taken and reduce the grievances/ problems that may arise expeditiously.

The tentative action plan and the measures suggested is given hereunder.

Year	Action Needed	Measures required for implementation/ Agency for Monitoring
1992	Announcement of India accepting Montreal Protocol	Public notice by Govt. of India by Ministry of Environment in all leading newspapers drawing the attention of affected parties.
	Amendment of Air Pollution Control Act 1981 to include CFC within its scope	Parliament
	Establishment of National Centre for Refrigeration & Air Conditioning	Department of Science & Technology
	Creation of a Board for implementation & monitoring of phase out strategy.	Department of Environment
	Sponsoring & funding of projects identified in R&D strategy including evaluation programme.	Deptt. of Science & Technology
1993	Start of Evaluation Programme	Jointly with Industry.
1994	Monitoring the production & consumption of CFCs in India	DGTD/Board for CFC phase out
	Ban of the use of CFC-12 in Air Conditioner, large Water Coolers and Cold Stores effective from 1.1.1998	DGTD/Board for CFC phase out
1996	Completion of evaluation programme	Jointly with Industry.
1998	Announcement of the 100% base for the Montreal Protocol Control	DGTD/Board for CFC phase out.
	Limiting of production & consumption of CFCs through quota system.	DGTD/Board for CFC phase out.
	Incentives for reduction in consumption of CFCs to be announced.	Department of Finance
	Import Policy of the CFCs substitute to be announced	Department of Commerce
	Modification of Licensing Policy for Refrigeration & Air Conditioning products in line with CFCs phase out policy.	Departent of Industrial Development

Year	Action Needed	Measures required for implementation/ Agency for Monitoring
	Incentives for purchase/import of recovery & recycling equipment.	Department of Industrial Development
	Incentives for recovery and/or recycling of CFCs gases	Department of Industrial Development
	Incentives for modification of Refrigeration & Air Conditioning equipment to facilitate recovery & recycling equipment.	Department of Industrial Development
	Incentives in industrial policy for import of know-how & technology for Refrigeration & Air Conditioning equipment based on CFCs substitute.	Department of Industrial Development

12. RECOMMENDATIONS

12.1 Recommendations of the Sub-group for Implementation

1. We should sign the Montreal Protocol as an Enironmentally conscious nation. Further amendments to the protocol are proposed by Committee in 12.2 below.

2. Immediate steps should be taken to establish an Administrative agency/CFC Phasing out Board/Ozone secretariat to work on all aspects of the measures suggested in Section 11.

3. Changing over from CFCs to Ozone friendly substitutes in terms of technology, processes, products and servicing practices is a major revolution facing the 2000 crores Refrigeration and Air Conditioning Sector. The effort required in terms of Education of Technical personnel and Customers, Research & Development required for evaluation, establishment and implementation of substitute technology and development of emission control technology is a massive job.

   The uncertainties which persist are likely to last for a very long time, optimistically up to 2030.

   Immediate steps must be taken for the establishment of a National Centre for Refrigeration & Air Conditioning.

   Immediate steps are also required for funding the R&D programmes on substitutes for CFC with collaboration between Laboratories, Industry and International Scientific Associations in this area.

4. Reducing the CFC requirements for recharging is likely to remain as a major problem even after new substitutes are implemented in the products manufactured during the phase out period.

   Immediate steps are necessary for taking up a major activity to develop 'Codes for better manufacturing and servicing practices' on lines of ASHRAE appropriate to Indian conditions.

5. This report is prepared based on the present level of knowledge on CFC substitutes and the present status of the Protocol. It will be necessary to update the report regularly.

   The standing committee with a small secretariat will have to be provided for the purpose.

12.2 Recommendations on Issues Related to Further Amendments to the Montreal Protocol

Proportionate Allocation of Quota

The amended Montreal Protocol treats all developing countries as a homogeneous block and prescribes the same treatment for all of them regardless of the state of their socio-economic development, consumption levels etc. There are more than 100 countries in this group accounting for over 50% of the world population and the requirements and problems of each are unique.

While finalising the phase-out schedule, it is well known that the practical considerations were kept in view by the developed countries regarding the impact of phase-out of controlled substances on socio-economic conditions and the status of development of substitute. For instance, in one year alone, developed countries would release about 850,000 MT of CFCs, no decision was taken to stop production and consumption immediately instead of a decade.

The allocation of per capita consumption limits is disproportionate at the moment and appears to be arbitary and the reasons thereof are not explained anywhere. For example, a tentative estimate puts India's consumption of the controlled CFCs at about 0.1 million tonne (absolute terms) upto the year 2000 on the assumption of unconstrained growth. The USA, after implementing control measures as per the amended Protocol, would consume about 2.2 million tonnes of CFC-11 and 12 upto year 2000. Corresponding figures on per capita basis work out to be 97 grams and 8461 grams for India and USA respectively.

Developed countries are already using HCFCs like HCFC-22 in large quantities and figures of consumption of HCFCs are likely to increase further by 2000 when they phase out CFCs completely. The ODP tonnage consumption in terms of HCFCs by these countries will be more than similar consumption with CFCs in an unconstrained growth scenario in developing countries at least for the next 20 years.

It may, therefore, be desirable to set a uniform norm of calculated level of consumption for all the countries beyond 2000.

This limit could cover all the Ozone Depleting Substances and may be fixed in proportion to each country's population. Once quotas are allocated, each country should be free to decide its own time frame.

Greenhouse Warming Issues

Although it is being talked about, Greenhouse Warming Potential is not yet a determining factor for the choice of substitutes in terms of the Protocol. If this gets included in the Protocol, the transition to environment friendly substitution will take place in two phases i.e.

1. From CFC to transitionary substitute (with low/zero ODP and some GWP).

2. From transitionary substitute to permanant substitute having zero ODP and zero GWP.

In that event, developing countries like India should insist on an extra grace period of 5 years, so that the economic burden on the country of two switchovers can be avoided.

There are authentic NASA reports to indicate that increase of grace period from 10 years to 15 years for developing countries does not materially affect the stratospheric influences on Ozone layer.

Continued Use of HCFC-22

The phase out scenarios worked out in this report are based on the assumption that use and availability of HCFC-22 will continue, beyond 2010 and therefore alternative Refrigeration & Air Conditioning Technologies based on the same could be developed and implemented. India should insist on a clear reaffirmation in the next meeting that till 2040 its status as a 'transitional substance' will not be altered, even if Global Warming Potential becomes a determining factor for choice of Ozone Depleting Substances.

APPENDIX-I

CONSTITUTION OF THE SUB-GROUP ON REFRIGERATION AND AIR CONDITIONING

Convenor	Dr. K.V.N. Rao	Chief of R&D, Kelvinator of India Ltd., Faridabad.
Members	Mr. B.J. Wadia	General Manager (Refrigeration) Godrej Ltd., Bombay.
	Mr. R.S. Iyer	Divisional Manager, Voltas Ltd., Thane
	Mr. R.M. Shende	Dy. General Manager SRF Ltd., New Delhi.
	Dr. R.S. Agarwal	Professor, Mechanical Engg., IIT, Delhi.
	Dr. Devotta S.	Dy. Director, NCL, Poona
	Dr. R.V. Venkataratnam	Dy. Director, IICT, Hyderabad
	Mr. R.P. Paranjpey	Vice President, Kirloskar Pneumatic Ltd., Pune
	Mr. G. Raghavendran	Chairman & Managing Director, M/s.Manali Petrochemicals, Madras.
	Mr. H.S. Dubey	Industrial Adviser, Directorate General of Technical Development, New Delhi.
	Dr. Jagdish Singh	Director, Department of Scientific and Industrial Research, New Delhi.
Special Invitees	Mr. Sandip Bhatia	Manager - Business Development, Navin Fluorine Industries, Bombay.
	Mr. A.P. Khurana	Executive Secretary, AIACRA, New Delhi.
	Mr. D. Ravindra	Manager Projects and R&D, Blue Star Ltd., Bombay.

APPENDIX II

DEFINITIONS

1. CFC means Chlorofluorocarbons (Aliphatic Organic Compounds containing only chlorine, fluorine and carbon).

2. HCFC means Hydrochlorofluorocarbons (Aliphatic Organic compounds containing only Hydrogen, Chlorine, Fluorine and Carbon).

3. HFC means Hydrofluorocarbons (Aliphatic Organic compounds containing only Hydrogen, Fluorine and Carbon).

4. ODP means Ozone Depletion Potential of a substance in relation to CFC-11 to which is assigned ODP value of 1.

5. ODS means Ozone Depleting Substances as given in Annexure A and Annexure B of the Protocol.

6. GWP means Global Warming Potential of a substance in relation to CFC-11 or CO_2 to which is assigned GWP value of 1 (Thus there will be two scales of GWP).

7. The Montreal Protocol or The Protocol : means the Protocol as amended in June 1990 in London.

8. Controlled Substancce means a substance listed in Annexure A or in Annexure B of the Protocol, whether existing alone or in mixture. These Annexures of the Protocol are reproduced in Appendix - III.

9. "Production" means the amount of controlled substance produced minus the amount destroyed by technologies to be approved by the Parties.

10 "Consumption" means production plus imports minus exports of controlled substances.

11 "RAC" means Refrigeration and Air Conditioning

12. "PU" Foam means Polyurethane Foam

13. "PAFT" means Programme for Alternative Fluorocarbons Toxicity Testing, being jointly implemented by major world CFC producers

14. "Calculated levels" of production, imports, exports and consumption means levels determined in accordance with following :

    a. Production by :

        i) Multiplying its annual production of each controlled substance by the ozone depleting potential specified in respect of it in Annex - A or Annex - B of the Protocol.

        ii) Adding together, for each such Group, the resulting figures ;

    b. Imports and Exports, respectively, by following, *Mutatis Mutandis,* the proceudre set-out in sub-paragraphs (a); and

    c. Cosumption by adding together its calculated levels of production and imports and subtracting its calculated levels of exports as determined in 1993, any export of controlled substances ;to non-Parties shall not be subtracted in calculating the consumption level of the exporting Party.

APPENDIX III

Substances Defined in the Montreal Protocol

	Substance	Ozone Depleting Potential
ANNEX A		
Group I	CFC 11	1.0
	CFC 12	1.0
	CFC 113	0.8
	CFC 114	1.0
	CFC 115	0.6
Group II	Halon 1211	3.0
	Halon 1301	10.0
	Halon 2402	(to be determined)
ANNEX B		
Group I	CFC 13	1.0
	CFC 111	1.0
	CFC 112	1.0
	CFC 211	1.0
	CFC 212	1.0
	CFC 213	1.0
	CFC 214	1.0
	CFC 215	1.0
	CFC 216	1.0
	CFC 217	1.0
Group II	Other specified halons	Not Available
Group III	Carbon tetrachloride	1.1
Group IV	Methyl chloroform	0.1

Annex C

Transitional substances

Group	Substance
Group I	
$CHFCl_2$	(HCFC-21)
CHF_2Cl	(HCFC-22)
CH_2FCl	(HCFC-31)
C_2HFCl_4	(HCFC-121)
$C_2HF_2Cl_3$	(HCFC-122)
$C_2HF_3Cl_2$	(HCFC-123)
C_2HF_4Cl	(HCFC-124)
$C_2H_2FCl_3$	(HCFC-131)
$C_2H_2F_2Cl_2$	(HCFC-132)
$C_2H_2F_3Cl$	(HCFC-133)
$C_2H_3FCl_2$	(HCFC-141)
$C_2H_3F_2Cl$	(HCFC-142)
C_2H_4FCl	(HCFC-151)
C_3HFCl_6	(HCFC-221)
$C_3HF_2Cl_5$	(HCFC-222)
$C_3HF_3Cl_4$	(HCFC-223)
$C_3HF_4Cl_3$	(HCFC-224)
$C_3HF_5Cl_2$	(HCFC-225)
C_3HF_6Cl	(HCFC-226)
$C_3H_2FCl_5$	(HCFC-231)
$C_3H_2F_2Cl_4$	(HCFC-232)
$C_3H_2F_3Cl_3$	(HCFC-233)
$C_3H_2F_4Cl_2$	(HCFC-234)
$C_3H_2F_5Cl$	(HCFC-235)
$C_3H_3FCl_4$	(HCFC-241)
$C_3H_3F_2Cl_3$	(HCFC-242)
$C_3H_3F_3Cl_2$	(HCFC-243)
$C_3H_3F_4Cl$	(HCFC-244)
$C_3H_4FCl_3$	(HCFC-251)
$C_3H_4F_2Cl_2$	(HCFC-252)
$C_3H_4F_3Cl$	(HCFC-253)
$C_3H_5FCl_2$	(HCFC-261)
$C_3H_5F_2Cl$	(HCFC-262)
C_3H_6FCl	(HCFC-271)

APPENDIX IV

REVISED PHASE-DOWN DATES AS APPLICABLE TO THE DEVELOPED AND DEVELOPED COUNTRIES

SUBJECT	MAJOR ADJUSTMENTS		
CHLOROFLUOROCARBONS (CFC-11, 12, 113, 114 & 115)	DEVELOPED COUNTRIES (Year)	Cut in PRODUCTION/ CONSUMPTION (from base year)	DEVELOPING COUNTRIES (Year)
Base Year Developed Nations - 1986 Developing countries- (average for the period between 1995 to 1997)	1989	FREEZE	1999
	1995	50%	2005
	1997	85%	2007
	2000	100%	2010

APPENDIX V

SELECT LIST OF REFRIGERATOR COMPRESSOR MANUFACTURERS ABROAD BASED ON HFC-134a

1. ASPERA
2. IRE
3. NECCHI
4. DANFOSS
5. MATSUSHITA
6. TOSHIBA
7. HITACHI
8. SICOM
9. EMBRACO
10. ZANUSSI

SELECT LIST OF CFC SUBSTITUTES MANUFACTURERS

World Producer	Plant Location	Size TPA	Commissioning	Commercial Availability	Substitute
Du Pont	Corpus Christi, Texas	10000	1991	1992	HFC 134a
	Japan	World Size	1992		HFC 134a
	USA	—	—	Available	HFC-152a
	USA	—	—	Available	Ternary Blend (HCFC-22/HFC-152a/ HCFC-124)
	Canada	—	1991	Available	HCFC-123
ICI	Runcorn, England	10000	1990	1991	HFC 134a
	St.Gabriel, Louisiana	10000	1992	1993	HFC 134a
Montefluos	Porto Marghera Italy				HCFC 123,141b,142b
Hoechst	Germany	5000	1992	1995	HFC 134a
Showa Denko	Japan	5000	1991	1993	HFC 134a
Daikin	Japan	Commercial Scale	1991		HFC 134a
Atochem	France Clavert City US	9000	1992 PAFT 1993		HFC 134a, HCFC 141b
China	(3 Plants)	250	—	Available	HFC-152a
Allied	USA	—	—	Available	HCFC-141b
Asahi Glass	Japan	800	1991	Available	HCFC-123

APPENDIX VII

A NOTE BY MR. R.M. SHENDE - MEMBER OF THE SUB-COMMITTEE REGARDING 'OBJECTIVES OF R&D STRATEGY'

Mr. R.M. Shende - Member of the Sub-Committee recommends inclusion of following in place of para (ii) of Chapter 9 under Objective of R&D (Page 80) :

> " ii) Evaluation and assessment of the substitutes in order to RECOMMEND to Indian industry the substitutes which are environment friendly (and not only ozone friendly) and appropriate to Indian conditions."

Relevant para under Executive Summary on Page 12 would also get modified accordingly.

Explanary note on above :

a) CFC-substitutes being investigated and/or commercialized by developed world, have either zero-ODP or low ODP. There are, however, other environmental concerns associated with these substitutes. Such concerns are related to global warming, ground level smogs, water pollution arising out of use of high boilers and effect on ozone by the decomposed constituents of the substitutes etc. As a developing country, we cannot afford frequent transitions. R&D programme, therefore, has to be targetted to recommend the long term and environment friendly substitutes to Indian industry for commercialization. Such approach will help India to avoid costly mistakes in future.

   If R&D programme is devised only "to give technical support" with Indian industry, above mentioned objective will not be achieved.

b) As the phase-down scenarios in the report are not based on the substitutes which are appropriate to Indian conditions, these scenarios are of hypothetical nature and should be considered only to understand the order of magnitude of costs involved in switch-over to substitutes.

-x-x-x-x-x-x-